International Parkinson and Movement Disorder Society Pan American Section
In collaboration with:
Baptist Health

Use of Focused Ultrasound in Movement Disorders

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COI disclosures

- Dr. Torres-Russotto is a consultant for AbbVie, Amneal, Neurocrine, Revance and Teva.
- None of the substances we will talk about have FDA approval.

Learning Objectives

- List different indications and contraindications for HIFU
- Review level of evidence of use of HIFU in PD, ET and Dystonia
- Enhance ability to recognize possible candidates for HIFU

Past results from the old Ablative Surgeries for PD: Pallidotomy &Thalamotomy

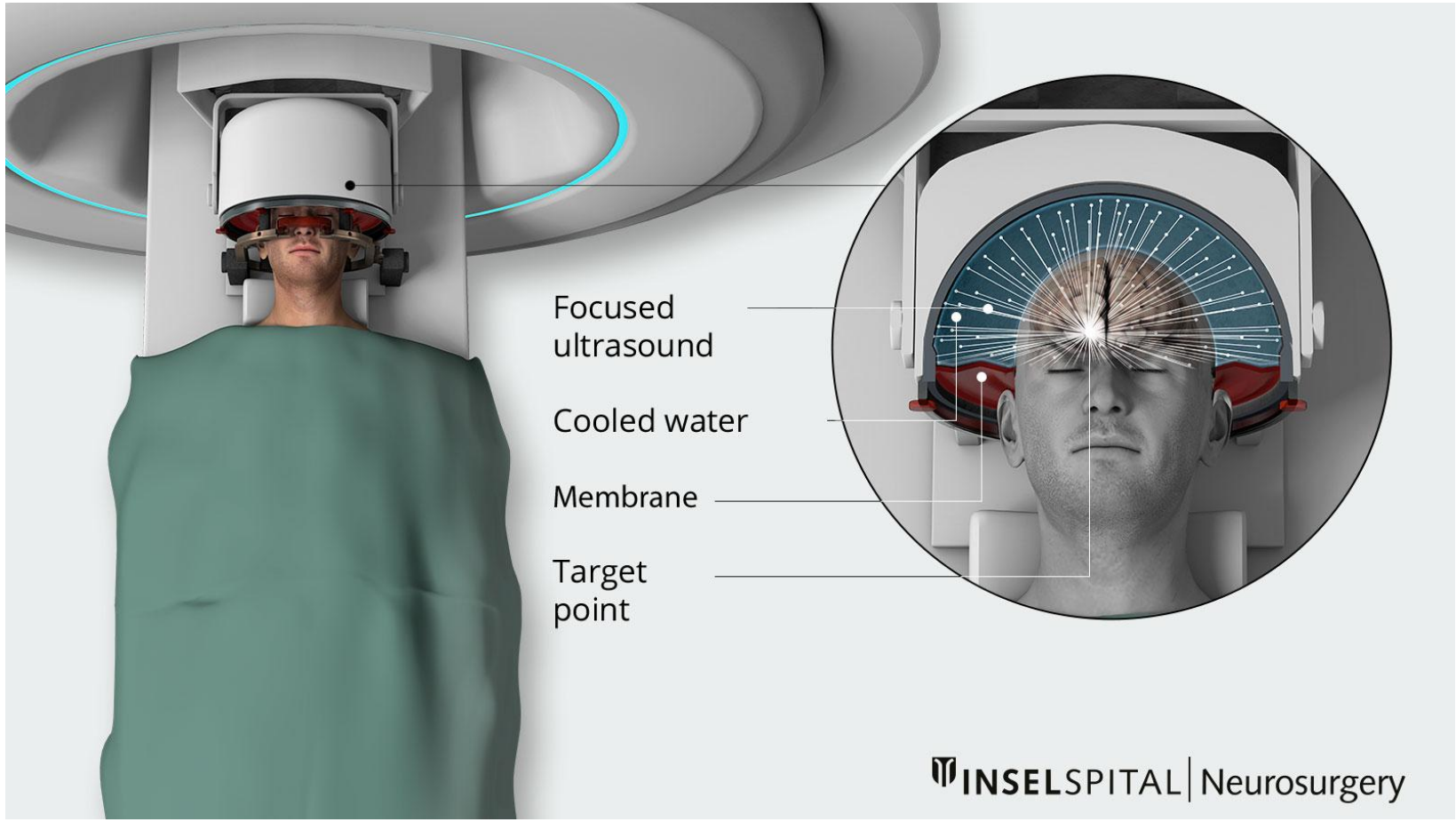
- Temporary and partial motor benefit
- Inconsistent benefit: location/size of the lesion?
- Irreversible adverse effects:
  - Partial blindness
  - Motor and sensory deficits
  - Hemorrhage
- Discouraging results of bilateral ablation:
  - Gait impairment
  - Dysarthria and dysphagia
  - Cognitive deficits

So why consider lesional surgeries all-over again?

- The technical advantages of MRgFUS are:
  - It is incisionless
  - Continuous intraoperative monitoring of clinical symptoms and MR images
  - Fine adjustment of the target by the steering function.
  - The ability to do a test drive

Overview of HIFU Technology

MRI-guided focused ultrasound (MRgFUS) transcranial thermoablation



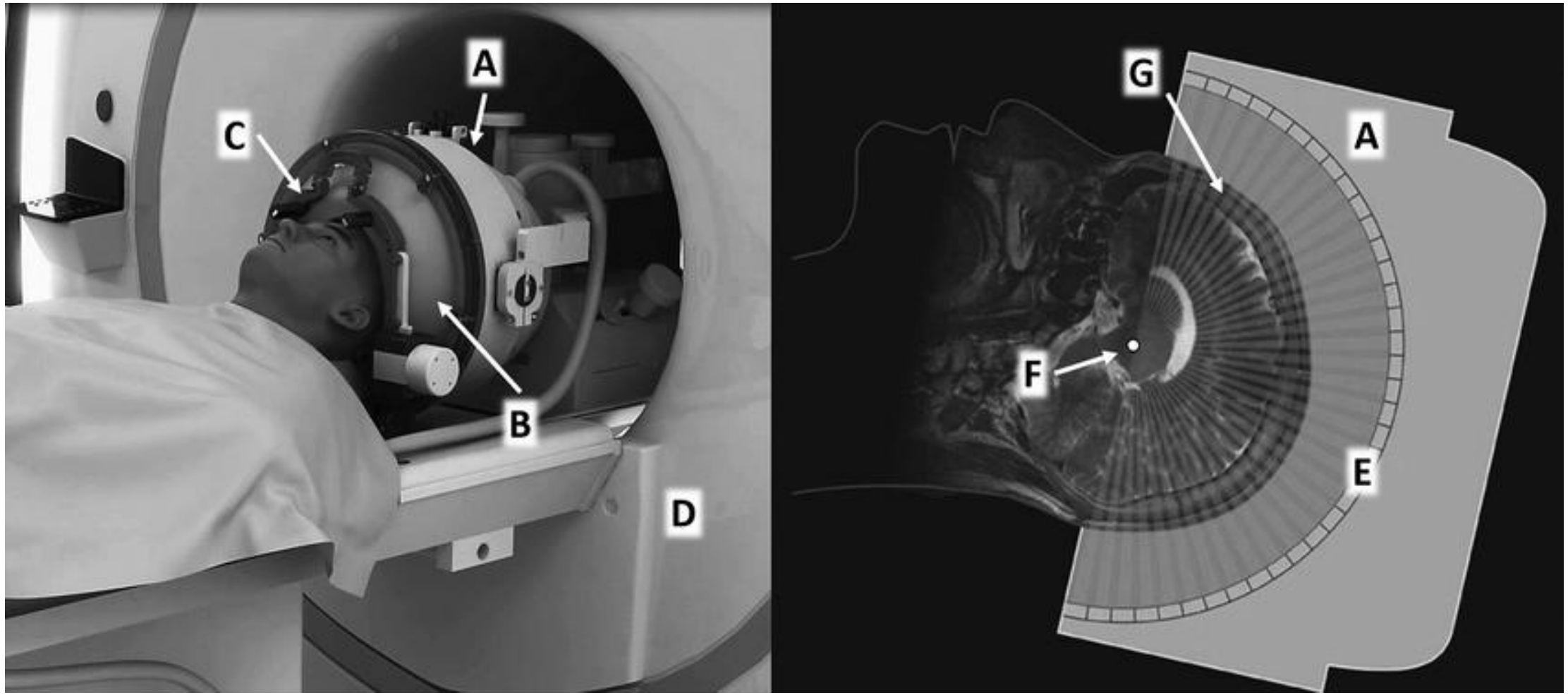
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MAESAWA, et al. (2021). Techniques, Indications, and Outcomes in Magnetic Resonance-guided Focused Ultrasound Thalamotomy for Tremor. Neurologia medico-chirurgica. 61. 10.2176/nmc.ra.2021-0187.

- The ultrasound transducer with 1024 elements emits ultrasound beams, which are then focused on the target with a phase control, resulting in optimal ablation by thermal coagulation.
- Postoperative tremor control is compatible with other modalities, although evidence for long-term follow-up is available up to about 5 years.
- Prognostic factors for good tremor control include high temperature and large lesion size.
- A high skull density ratio is a factor to achieve high temperature and large lesioning, but it may not be necessary and sufficient for clinical outcomes.

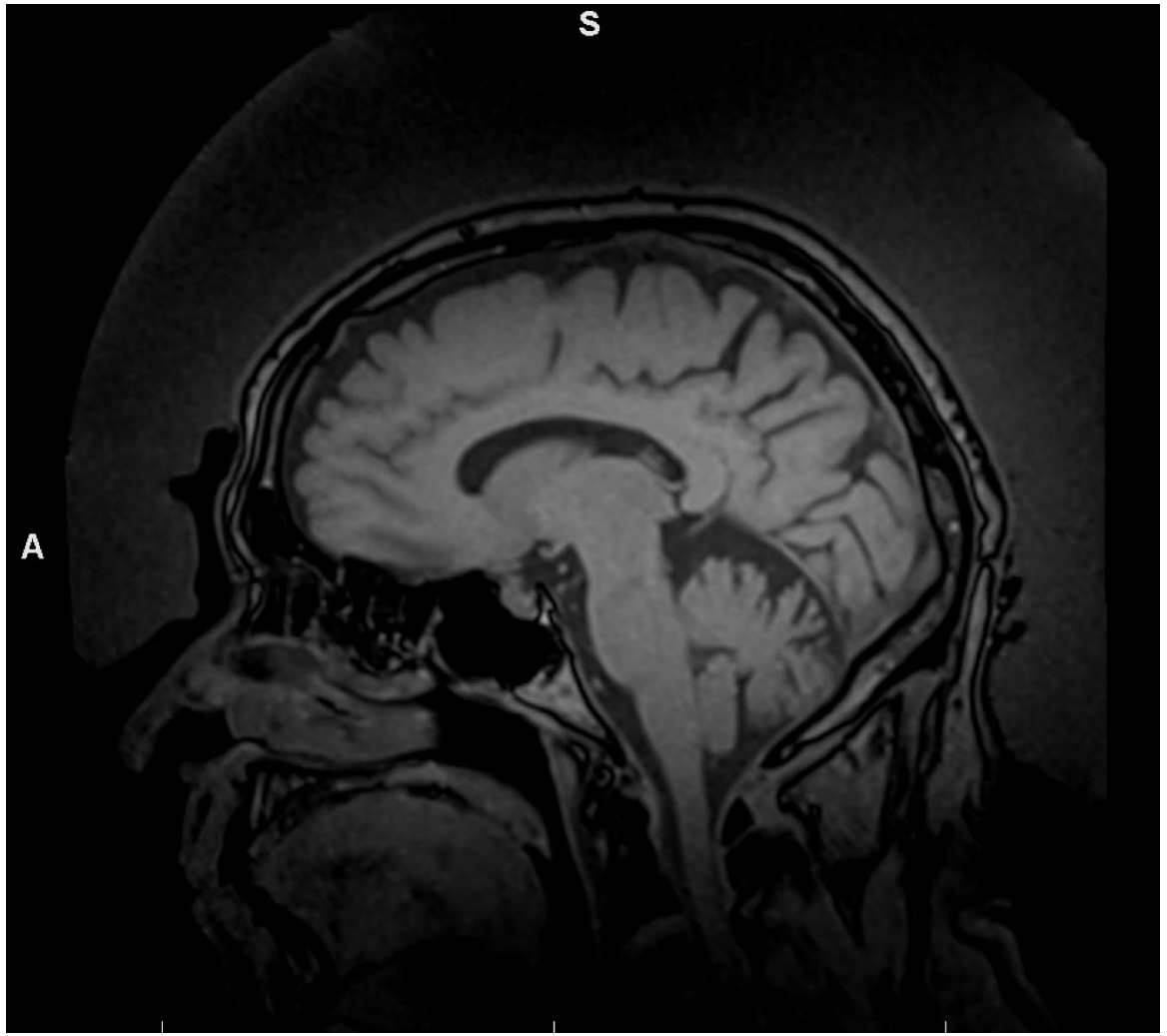
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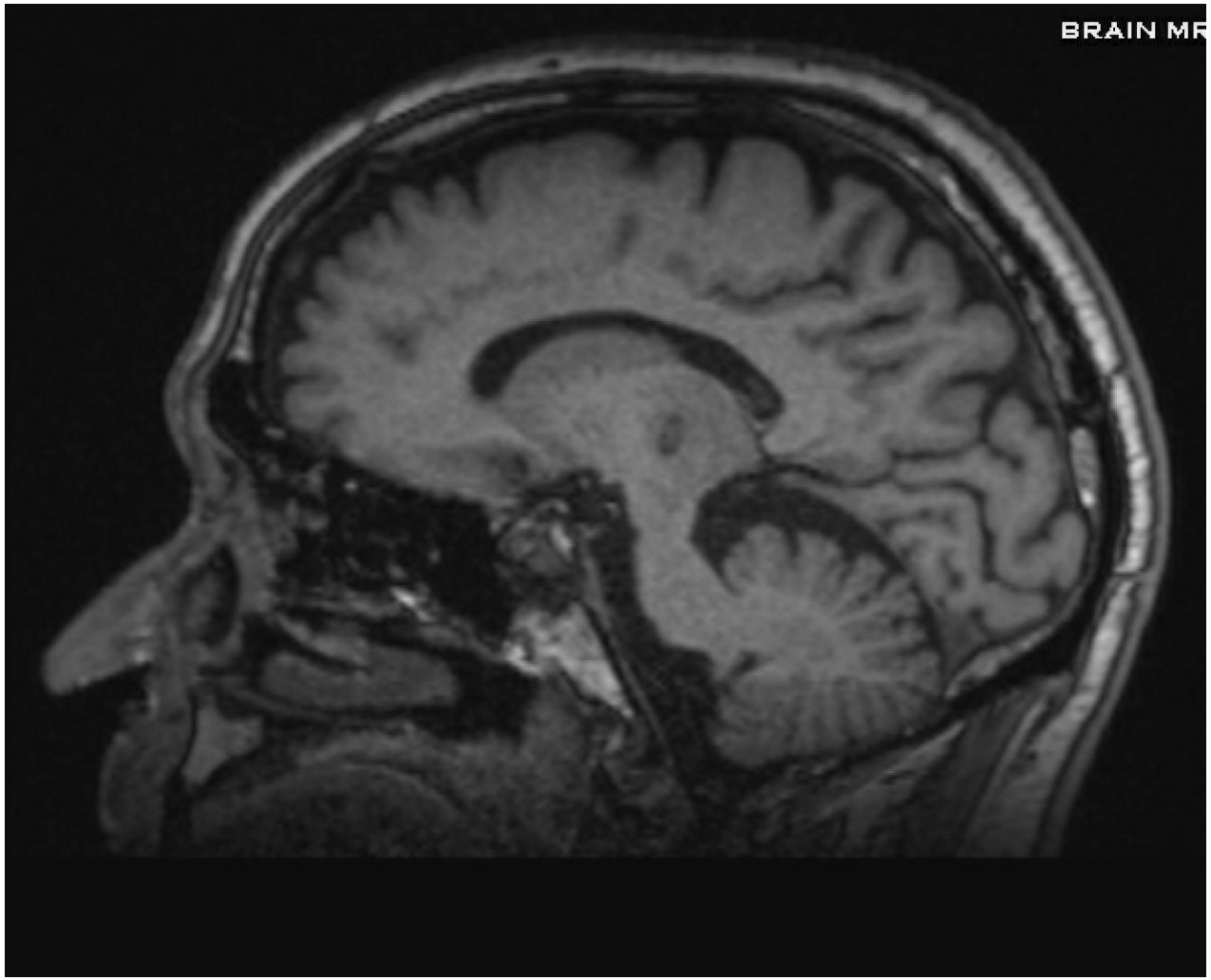
SKULL THICKNESS AND ABILITY TO REACH TARGET

- **How many candidates are ineligible based on conventional skull density ratio (SDR) cutoff of 0.40 ?**
  - 10–30% of candidates in Western series
  - 50-80% in East Asian populations
- **How many patients remain untreatable?**
  - Below 0.40, thermal efficiency falls but tremor outcomes stay comparable.
  - Skull-related treatment failure, meaning no lesion can be made, runs at about 3–11%.
  - Label: the FDA labeling lists SDR ≤0.45 (±0.05) as a contraindication. Most clinicians treat 0.40 as the practical floor (and some places SDR ≥0.35).

Yamamoto et al. (2019), Ventralis intermedius thalamotomy with focused ultrasound for patients with low skull density ratio. Mov Disord, 34: 1239-1240. https://doi.org/10.1002/mds.27726
D'Souza M, et al. Impact of skull density ratio on efficacy and safety of magnetic resonance-guided focused ultrasound treatment of essential tremor. J Neurosurg. 2019 Apr 26;132(5):1392-1397. doi: 10.3171/2019.2.JNS183517.

What's in a name? Non-Invasive, minimally-invasive, non-incisional?

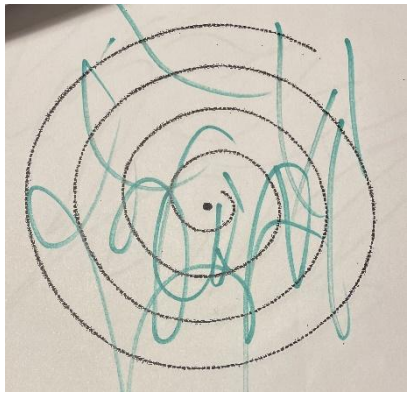


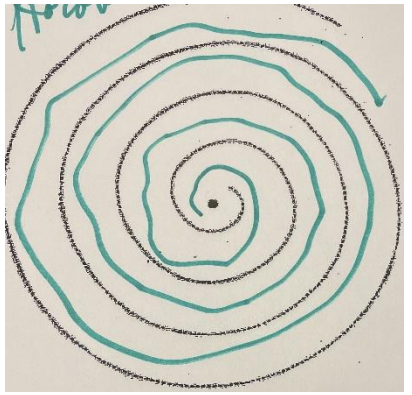


Test Drive

- HIFU allows to deliver lower energy first, “stunning” the abnormal brain cells, but not causing permanent damage

- The team tests patient’s tremor
  - Drink from a glass
  - Draw a spiral
  - Write their name
  - Finger to nose



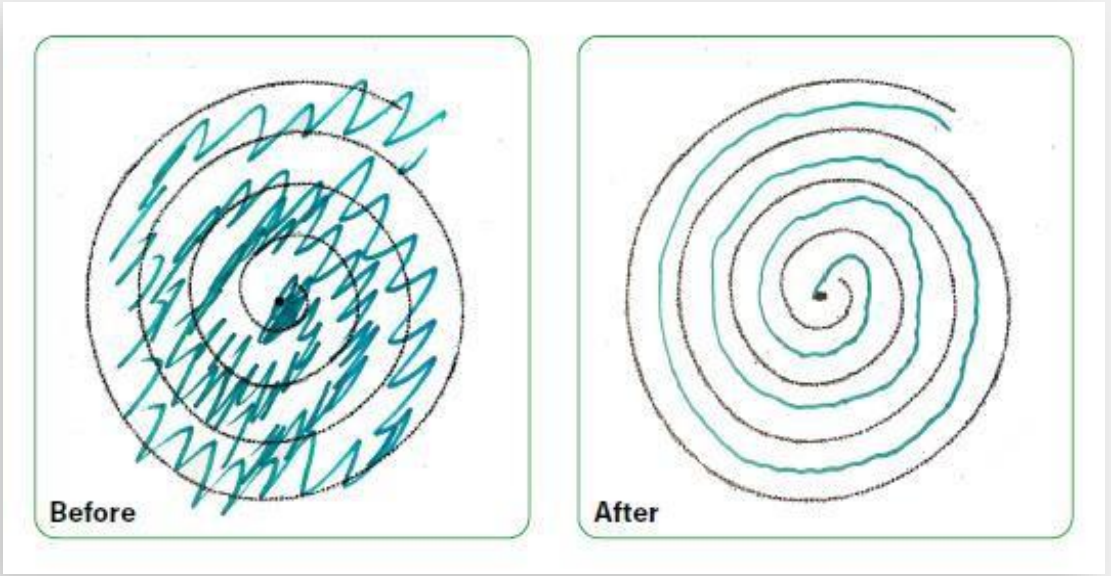


- If no improvement, may need to move target
- If good improvement, increase energy and cause permanent ablation

HIFU for Essential Tremor

HIFU: Game-Changing Treatment for Essential Tremor





HIFU: Game-Changing Treatment for Essential Tremor





Indication / target	Best evidence	Efficacy	Durability	Key complications
ET – unilateral Vim thalamotomy	**Sham-controlled RCT (n=76); 5-yr cohorts**	47% hand-tremor improvement at 3 mo	**Postural tremor still 73% better at 5 yr;** tremor/motor 40–52%	**Gait disturbance 36% and paresthesia 38% early; 9% and 14% persisted at 12 mo**
ET – staged bilateral Vim	Open-label trial (n=51); **real-world cohorts**	**62–66% total tremor reduction**; axial tremor improves	12 mo	**Dysarthria and dysgeusia more frequent than after unilateral; AEs more persistent after the 2nd side**

1.Magnetic Resonance Imaging-Guided Focused Ultrasound Thalamotomy for Essential Tremor: 5-Year Follow-Up Results.
Journal of Neurosurgery. 2023. Cosgrove GR, Lipsman N, Lozano AM, et al.
2.Unilateral Magnetic Resonance-Guided Focused Ultrasound for Medication-Refractory Essential Tremor: 5-Year Continued Access Study.
Frontiers in Neurology. 2025. Ghanouni P, Krishna V, Eisenberg HM, et al.
3.A Randomized Trial of Focused Ultrasound Thalamotomy for Essential Tremor.
The New England Journal of Medicine. 2016.Elias WJ, Lipsman N, Ondo WG, et al.

Overall Long-Term Efficacy and Safety in ET

TIME POINT	TREMOR IMPROVEMENT	FUNCTIONAL DISABILITY IMPROVEMENT
1 Year	~64%	64%
3 Years	53.1%	56.9%

https://www.ajnr.org/content/35/5/891

HIFU for ET: Important Questions

- Does it provide long-term benefit?
  - YES, up to 5 years,
  - But it decreases over time. About 11% had tremor return that affected daily activities by 5 years

- Long-term neurological complications?
  - At 5 years, AEs were 85% mild, 12% moderate and 3% severe.
  - Sensory complications:
    - One patient with permanent dense hypesthesia of two fingers.
  - Two patients had capsular weakness lasting 6–12 months.

The New England Journal of Medicine. 2016.Elias WJ, Lipsman N, Ondo WG, et al.
Frontiers in Neurology. 2025. Ghanouni P, Krishna V, Eisenberg HM, et al.
Journal of Neurosurgery. 2023. Cosgrove GR, Lipsman N, Lozano AM, et al.

HIFU for ET: Important Questions (cont)

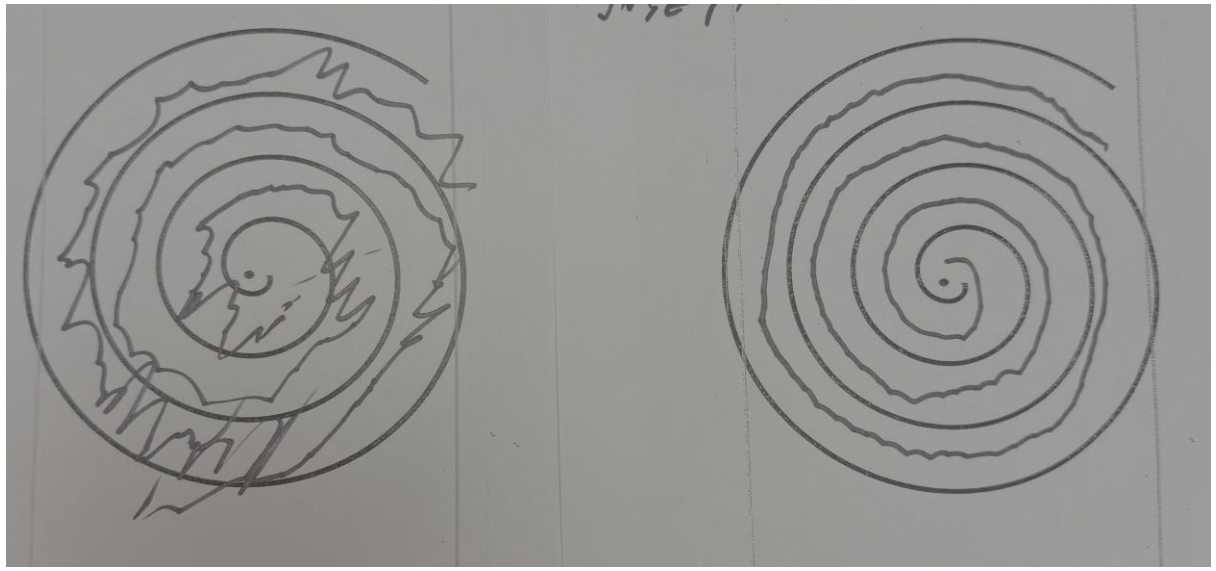
- Can we do Staged Bilateral HIFU for ET safely?
  - YES, but with more SEs
  - Open-label trial reported a 62% tremor reduction at 12 months, with AE frequency comparable to unilateral treatment.
  - AEs were more frequent and more persistent after the second side.
  - Pooled data shows dysarthria rising from 2% to 24% and taste disturbance from 5% to 20% with bilateral treatment.

- Can we repeat same side for recurrence?
  - Tremor control after a repeat procedure is comparable to the first, but side effects are more common (any side effect at 1 month: 96.6% vs 69.0%), with larger lesions.

JAMA Neurology. 2024. Kaplitt MG, Krishna V, Eisenberg HM, et al
Movement Disorders. 2026. Vilas D, Gonzalez A, Tardáguila M, et al.
Movement Disorders. 2026. Glaser AC, Chua MMJ, Mazurek M, et al.

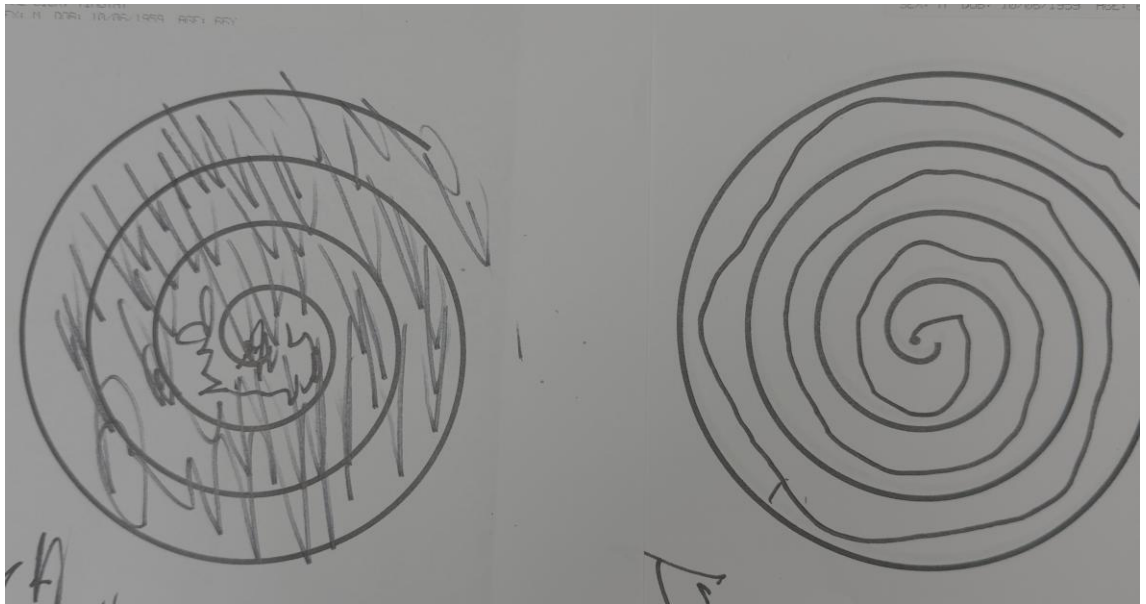
HIFU for Parkinson Disease

Pre- and post-HIFU Tremor examples



Essential Tremor

PD action Tremor



PD TREMOR

Indication / target	Best evidence	Efficacy	Durability	Key complications
PD tremor – Vim thalamotomy	Pilot sham RCT (n=27); cohorts	62% vs 22% (sham) at 3 mo	Waning benefit; complete recurrence ~17%	Transient hemiparesis from capsular heating; gait and sensory effects

Safety and Efficacy of Focused Ultrasound Thalamotomy for Patients With Medication-Refractory, Tremor-Dominant Parkinson Disease: A Randomized Clinical Trial.JAMA Neurology. 2017. Bond AE, Shah BB, Huss DS, et al.RCT

Outcomes of Focused Ultrasound Thalamotomy in Tremor Syndromes.Movement Disorders. 2024. Peters J, Maamary J, Kyle K, et al.

Patient-Reported Outcomes After Focused Ultrasound Thalamotomy for Tremor-Predominant Parkinson's Disease.
Neurosurgery. 2023. Maragkos GA, Kosyakovsky J, Zhao P, et al.

Overall Expectations in PD

OUTCOME MEASURE	BASELINE	POST-HIFU
UPDRS III Score	19.9	9.9 (4 months)
MDS-UPDRS III Score	16.6	7.5 (6 months)
Mean Improvement	-	~33.9%

Non-Tremor motor benefit

Indication / target	Best evidence	Efficacy	Durability	Key complications
PD – unilateral STN	Sham RCT (n=40); 3- and 5-yr cohorts	Treated-side off-med score 19.9→9.9 vs 18.7→17.1 (sham)	Treated-side benefit kept at 5 yr; fluctuations and QoL return to baseline	Speech, gait, weakness, dyskinesia; deficits at 12 mo in 22%
PD – unilateral GPi pallidotomy	Sham RCT (n=94)	Response 69% vs 32% (sham) at 3 mo	30/39 responders still responding at 12 mo	Dysarthria, gait, taste loss, visual and facial effects (mostly mild)
PD – staged bilateral PTT (pallidothalamic tractotomy)	Single-arm multicenter trial (n=40 bilateral)	32% motor improvement	12 mo after 2nd side	25% persistent moderate/severe speech, gait or balance AEs; 1 severe anarthria

Randomized Trial of Focused Ultrasound Subthalamotomy for Parkinson's Disease. The New England Journal of Medicine. 2020.Martínez-Fernández R, et al.

Prospective Long-Term Follow-Up of Focused Ultrasound Unilateral Subthalamotomy for Parkinson Disease. Neurology. 2023. Martínez-Fernández R, et al

Five-Year Follow-Up of Unilateral Focused Ultrasound Subthalamotomy for Parkinson's Disease. Movement Disorders. 2026. Natera et al

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Trial of Globus Pallidus Focused Ultrasound Ablation in Parkinson's Disease.
The New England Journal of Medicine. 2023.Krishna V, et al.
Focused Ultrasound Ablation of the Globus Pallidus Internus for Parkinson's Disease. The New England Journal of Medicine. 2023.Schrag A.O et al.

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Safety and Efficacy of Staged, Bilateral Magnetic Resonance-Guided Focused Ultrasound Pallidothalamic Tractotomy for Motor Complications of Parkinson's Disease: A Prospective, Multicentre, Single-Arm Trial.
The Lancet. Neurology. 2026. Dalvi A, Eisenberg HM, Wu P, et al.

HIFU for PD: Important Questions

- Should we consider VIM HIFU for tremor-predominant PD?
  - YES, safe and effective.
  - But, long-term durability is a concern

- What's the best lesion size for VIM HIFU in Tremor-predominant PD?
  - Lesion volume trades efficacy against complications: One proposed window is about 145–220 mm^3

Journal of Neurosurgery. 2026. Hamani C, Elias WJ, Baltuch GH, et al.
Movement Disorders. 2025. Braccia A, Golfrè Andreasi N, Ghielmetti F, et al.

HIFU for PD: Important Questions (cont)

- Is unilateral HIFU safe when used for motor PD?
  - YES, safe and effective.
  - But, long-term persistent mild deficits (reduced verbal fluency, dysarthria, a clumsy hand). Cognition was unchanged

- Is unilateral HIFU benefit in PD sustained?
  - It's complicated: At 5 years, treated-side motor benefit is maintained (with higher use of meds). 81% report global improvement
  - However, off-time, fluctuations, MDS-UPDRS II and PDQ-39 return to baseline (the untreated side progresses?).

Neurology. 2023. Martínez-Fernández R, Natera-Villalba E, Máñez Miró JU, et al. Movement Disorders : Official Journal of the Movement Disorder Society. 2026. Natera-Villalba E, Martínez-Fernández R, Jiménez-Castellanos T, et al.

HIFU for PD: Important Questions (cont)

- Is bilateral HIFU effective and safe when used for motor PD?
  - Staged bilateral STN in 6 patients gave a 52.6% motor improvement.
  - But SE/complications were a lot more common.

- Is unilateral HIFU benefit in PD sustained?
  - It's complicated: At 5 years, treated-side motor benefit is maintained (with higher use of meds). 81% report global improvement
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HIFU for Dystonia

Thalamic Targets in Dystonia

Indication / target	Best evidence	Efficacy	Durability	Key complications
Dystonia – Vo thalamotomy	Pilot (n=10) and case reports	Writer's cramp score −71%; musicians returned to playing	12 mo; early recurrence in 3/10	Facial palsy (2 patients)
Dystonic tremor – Vim thalamotomy	Single-center cohort (n=24)	61% tremor improvement at 24 mo	Similar to ET, with a trend toward waning	Dystonia unchanged or worse in tremor–dystonia cases

Magnetic Resonance-Guided Focused Ultrasound Thalamotomy for Focal Hand Dystonia: A Pilot Study.
Movement Disorders. 2021. Horisawa S, Yamaguchi T, Abe K, et al.
A Single Case of MRI-guided Focused Ultrasound Ventro-Oral Thalamotomy for Musician's Dystonia.
Journal of Neurosurgery. 2019. Horisawa S, Yamaguchi T, Abe K, et al

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Focused Ultrasound for Treatment of Movement Disorders: A Review of Non-Food and Drug Administration Approved Indications. Stereotactic and Functional Neurosurgery. 2023. Cummins DD, et al
Outcomes of Focused Ultrasound Thalamotomy in Tremor Syndromes.
Movement Disorders. 2024. Peters J, Maamary J, Kyle K, et al.

HIFU for Dystonia: Important Items

- **Pallidal targets for focal or generalized dystonia** are used only rarely, with concern about permanent speech effects.

- **Tremor plus dystonia:** Vim lesions reduce tremor by more than 50% but do not improve the dystonia, which even worsened in some patient
- **MS tremor and ataxic tremor:** Evidence is anecdotal (n=3 each). Tremor improved in patients with a favorable skull density ratio, and ataxia did not worsen
- **A lot more data is still needed.**

Journal of Neurosurgery. 2026. Hamani C, Elias WJ, Baltuch GH, et al.
Movement Disorders. 2025. Braccia A, Golfrè Andreasi N, Ghielmetti F, et al.

HIFU
In Summary

Summary of SEs and complications

- Manufacturer post-marketing surveillance reports AEs in 1% of 19,850 procedures and in 0.41% of 6,997 more recent procedures.
- No cognitive decline has been reported

Advantages

- Non-invasive, no incision
- No hardware to worry about (infection, replacement)
- “test drive” ability
- Effective for tremor
- No worries about Imaging contraindications or artifact
- If done first, patients may consider DBS later in different targets (likely not for tremors)
- Seems better than previous historical lesional surgeries
- May have the advantage for Tremor PD patients with MCI / cognitive symptoms.

Drawbacks

- It is a lesion-based procedure
- Shaved head
- Skull thickness eliminates a significant number of cases
- Not modifiable after treatment
- Not as good to treat non-tremor symptoms
- Like every procedure, it has possible short and long-term complications
- Temporary (1-3 mo) numbness of face/hand and difficulty walking
- Significant limitations for bilateral treatments

HIFU vs DBS

FEATURE	HIFU	DEEP BRAIN STIMULATION
Incisions	No	Yes
Anesthesia	Not required	Required
Recovery Time	Same day discharge	Several days
Hardware	None	Implanted electrodes
Real-time Monitoring	MRI-guided	Limited
Long-term modulation	None	Maximum
Tremor benefit (short/Long term)	++++ / ++	++++ / +++
PD motor symptoms	++	++++

Which one is safer, HIFU vs DBS?

- More persistent deficits of HIFU compared with DBS:
  - A pooled analysis found persistent complications more common after MRgFUS than DBS.
- A 2026 meta-analysis:
  - Higher risks of gait instability (RR 2.85) and dysphagia (RR 3.40) with MRgFUS, with no difference in hemorrhage.

The punch line

- MRI-guided focused ultrasound thermoablation has its strongest, most durable evidence in essential tremor (ET).
- Parkinson's disease (PD) is supported by randomized trials of thalamotomy for tremor and of subthalamotomy and pallidotomy for broader motor symptoms.
  - In PD, tremor control after thalamotomy lasts less reliably than in ET
  - Motor benefit after subthalamotomy and pallidotomy comes with more speech, gait and dyskinesia complications long-term.
- Use in dystonia, dystonic tremor and other tremors is still investigational and based on small series.
- For patients with severe bilateral tremor or head/neck tremor, DBS may be preferable because of the adjustability of stimulation and the possibility of bilateral treatment.



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