



C5-MR-GUIDED FOCUSED ULTRASOUND (MRGFUS)

OBJECTIVES

- Compare Parkinson's Disease vs Essential Tremors
- Discuss Magnetic Resonance-Guided Focused Ultrasound (MRgFUS)
- Discuss Potential Candidates
- Define Procedure Steps
- Review Results
- Discuss the Future of MRgFUS

PARKINSON'S DISEASE

- Parkinson's disease is a progressive brain disorder that affects muscle control, balance, and movement.
- Treatments include deep-brain stimulation (DBS) and a dopamine drug called levodopa.
- The low amount of dopamine-producing neurons leads to a deficiency that results in bradykinesia (slowness of movement) and tremors.
- The average age of onset for Parkinson's disease is **60 years old**.
- More commonly found in males.

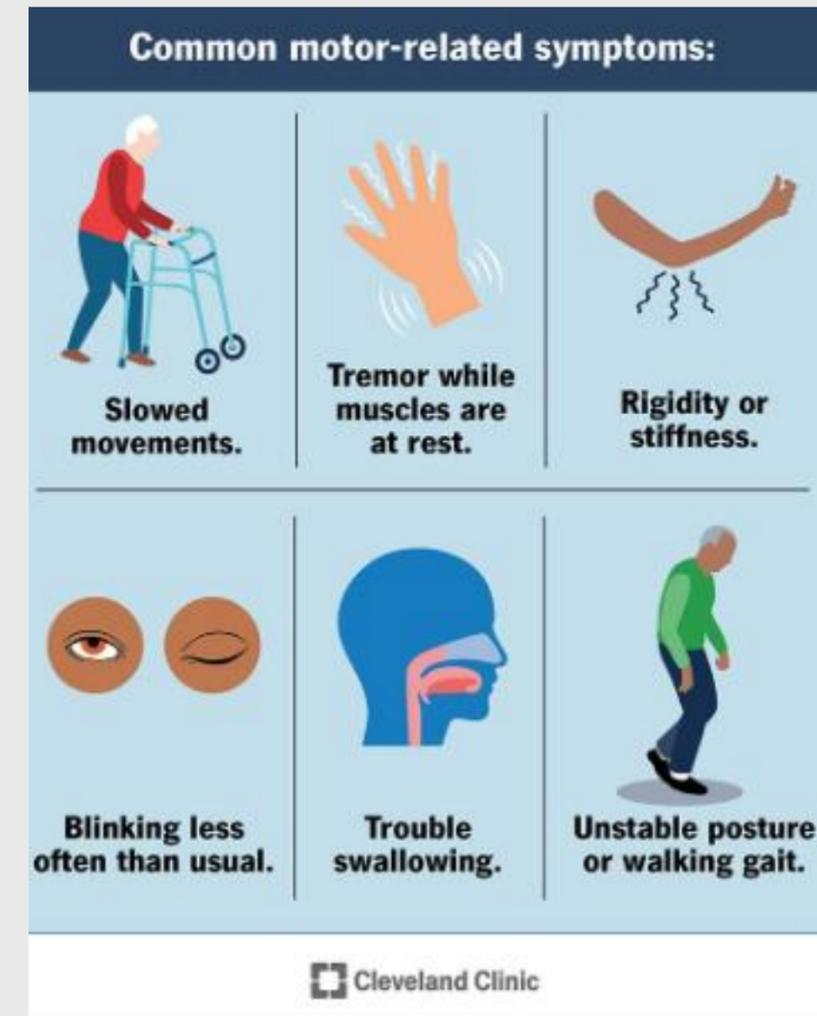


Figure 1. Symptoms of Parkinson's Disease (Source: *Cleveland Clinic- Parkinson's Disease*, 2025).

ESSENTIAL TREMOR

- Essential tremor is a movement disorder characterized by uncontrollable shaking of the head, voice, and upper and/or lower extremities.
- Treatments include deep-brain stimulation (DBS), beta-blockers, and anti-seizure drugs such as propranolol and primidone.
- The average age of onset for essential tremor is between the ages of **10 and 19** or between **50 and 59** years old.
- Familial tremor- this disorder tends to run in families.

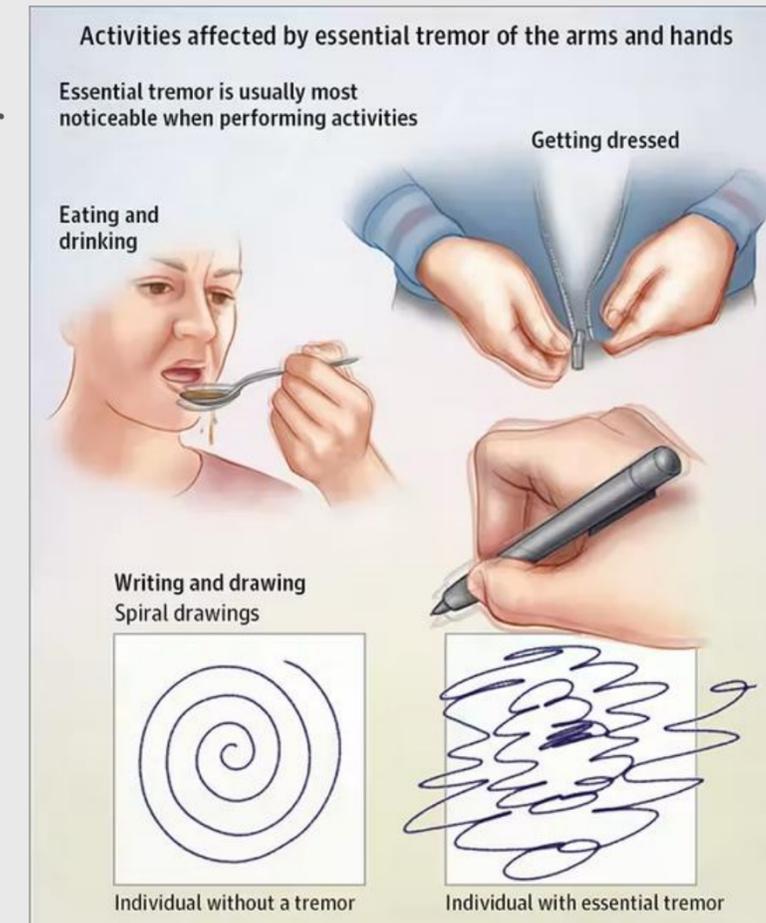


Figure 2. Symptoms of Essential Tremor (Source: Zindler, 2025).

INTEGRATING MRI AND ULTRASOUND

- **MRI** produces detailed images of the internal structures and organs of the human body. MRI mapping uses magnets to generate a strong magnetic field that aligns the protons in the human body.
- Radiofrequency pulses from the MRI machine temporarily misalign the protons, and when the frequency passes through the patient, the protons return to their original position. As they realign, the protons emit an electromagnetic signal that contains information, and this process is repeated continuously to create a 2D image that may be reconstructed into 3D (*National Institute of Standards and Technology, 2025*).
- **Focused ultrasound** is a non-invasive procedure that uses high-intensity sound waves to target and ablate specific tissue areas while minimizing damage to the surrounding structures.
- It employs an acoustic lens to concentrate high-energy sound waves, generating heat that destroys a particular area of the brain associated with tremors.
- Combining these two modalities led to the development of **MR-guided focused ultrasound**.

MAGNETIC RESONANCE-GUIDED FOCUSED ULTRASOUND (MRGFUS)

- Guided by magnetic resonance imaging, **1024 beams** of ultrasound are concentrated on a specific area of the brain. The sound waves generate heat that destroys the targeted tissue while not affecting the surrounding area.
- Unlike deep-brain stimulation, it does not involve any implanted hardware or devices. Using real-time MRI guidance, physicians can achieve high success rates with minimal risk and accurate 3D imaging. Since the procedure is non-invasive, patients typically recover quickly and are discharged the same day or within **24 to 48 hours**.

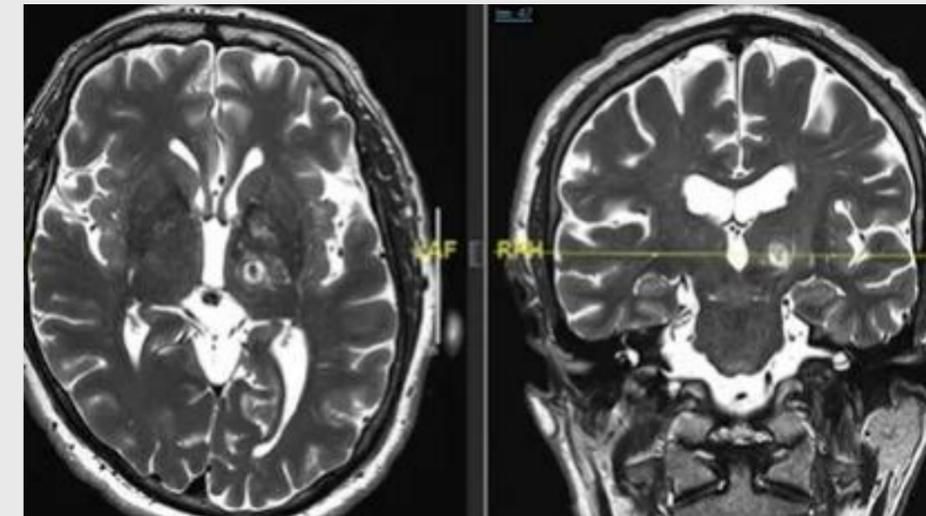


Figure 3. MRgFUS image on the thalamus (Source: Lak et al., 2022).



Figure 4. MR-guided focused ultrasound (Source: Duncan, 2020).

(Cleveland Clinic, 2025)

POTENTIAL CANDIDATES

- All patients considering this treatment must undergo a screening process that includes meeting with a neurologist, a motor skills evaluation, and a neuropsychological evaluation to assess motor and cognitive abilities.
- CT scan is required to measure skull thickness for calculating sound wave penetration (skull density ratio/other gross findings).
- Patients with implanted brain stimulators are disqualified from this procedure. In addition, if the patient's skull is too thick, the focused ultrasound waves may not penetrate deeply enough to produce an effective lesion.

DAY OF PROCEDURE

Step 1: Preoperative nurses shave the patient's head (essential for optimal transmission of ultrasound waves).

Step 2: Local anesthesia is applied around the shaved area of the scalp, and a head frame is secured to the patient's head to ensure stability during the procedure.

Step 3: Once the neurosurgeon confirms that the head frame is securely in place, a cooling helmet with circulating water is attached around the top of the head to prevent scalp overheating caused by the acoustic lens, which focuses approximately **1024** ultrasound beams on the thalamus.

Step 4: A series of MRI scout images will be taken to help plan the treatment. The neurosurgeon uses a low-intensity ultrasound pulse until the MR and ultrasound transducers are appropriately aligned, then adjusts the beam strength to the specific tissue target (*Stanford Health Care, n.d.*).



Figure 5. Headframe for MRgFUS (Source: *Student Host Hospital, 2025*).

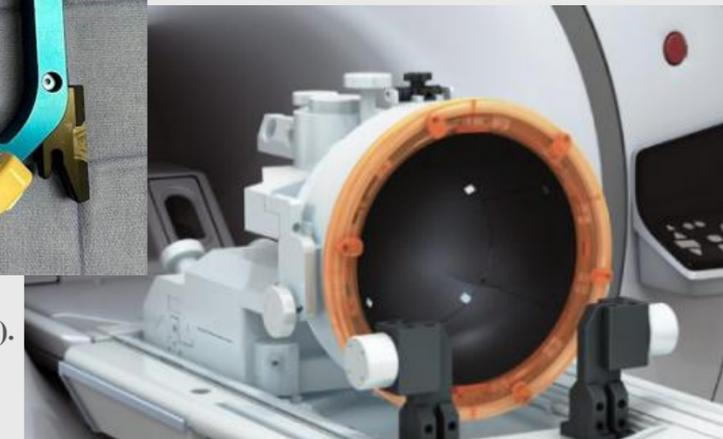


Figure 6. Cooling helmet (Source: *Jonker, B., 2021*).

(*Cleveland Clinic, 2025*)

PROCEDURE CONTINUED

Step 5: After each sonication, a high-frequency sound waves to agitate tissue, the neurosurgeon asks the patient to perform specific tasks to assess tremor improvement.

Step 6: The neurological team will give the patient various tasks that include drawing spirals and performing hand exercises to monitor movement and muscle control (*Hayden, Holly, 2025*).

Step 7: The neurosurgical team continuously fine-tunes and applies high-frequency energy to create a permanent lesion. Upon the lesion creation, the MRI technologist acquires a final series of MR images to evaluate the treatment's effectiveness in the targeted area (*Baylor College of Medicine, n.d.*).

Step 8: It usually takes **4-5 sonication**, but once the lesion is created, the patient can see instant improvement in their motor skills (*Hayden, Holly, 2025*).

Step 9: After the procedure, the patient is monitored by nursing staff for several hours and is typically discharged the same day or within **24 to 48 hours** (*Cleveland Clinic Medical, 2025*).



Figure 7. Drawing Spirals during MRgFUS (Source: Jonker, B., 2021).

EARLY INSIGHTS

- According to the FDA, over **50%** of patients with essential tremor have reported improvement in their tremor and motor skills after MR-guided focused ultrasound (*Cleveland Clinic Medical, 2025*).
- Parkinson's disease patients have reported an average improvement of **62%** in hand tremors (*Cleveland Clinic Medical, 2025*).
- Patients can immediately experience the results after the MRgFUS procedure.
- Insightec's five-year follow-up, approximately **75%** of patients experience a reduction of tremors (*Hayden, Holly, 2025*).
- Patients who show significant improvement typically schedule their next treatment **9-12 months later** (*Hayden, Holly, 2025*).
- MRgFUS can only be performed on one hemisphere of the brain at a time (*Hayden, Holly, 2025*).
- MR-guided focused ultrasound is generally a sedation free procedure, allowing patients to return home the same day with immediate improvement and minimal restrictions.
- Nurses may administer medication such as Zofran for nausea and Tylenol for headaches after the procedure.
- MR-guided focused ultrasound is considered a relatively safe procedure with minimal risk.
- As with any medical procedure, potential complications may include blood clots, skin burns, or scar formation.

(Stanford Health Care, n.d.)

RESULTS

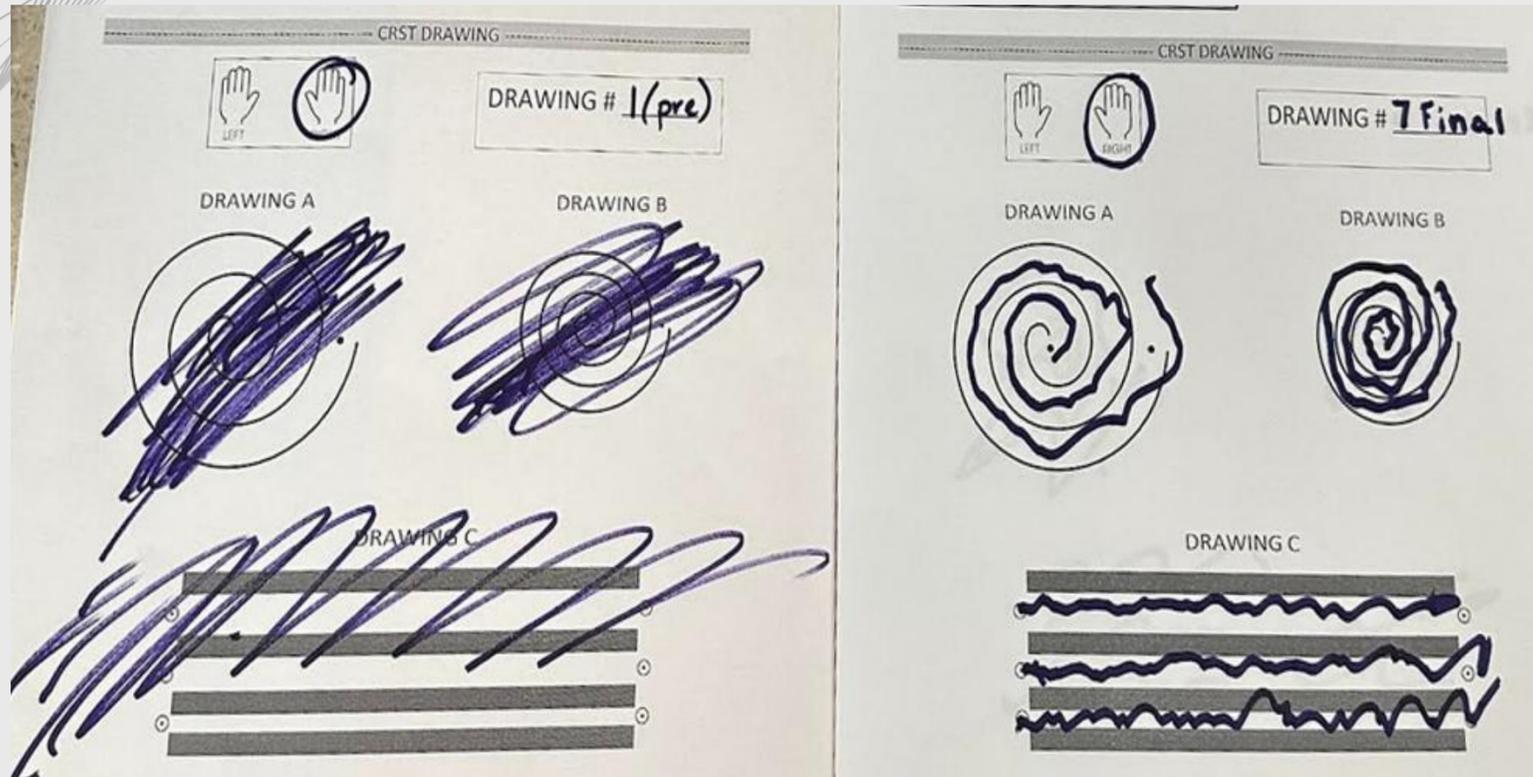


Figure 8. Pre-treatment and Post-treatment of MRgFUS (Source: *Student Host Hospital*, 2025).

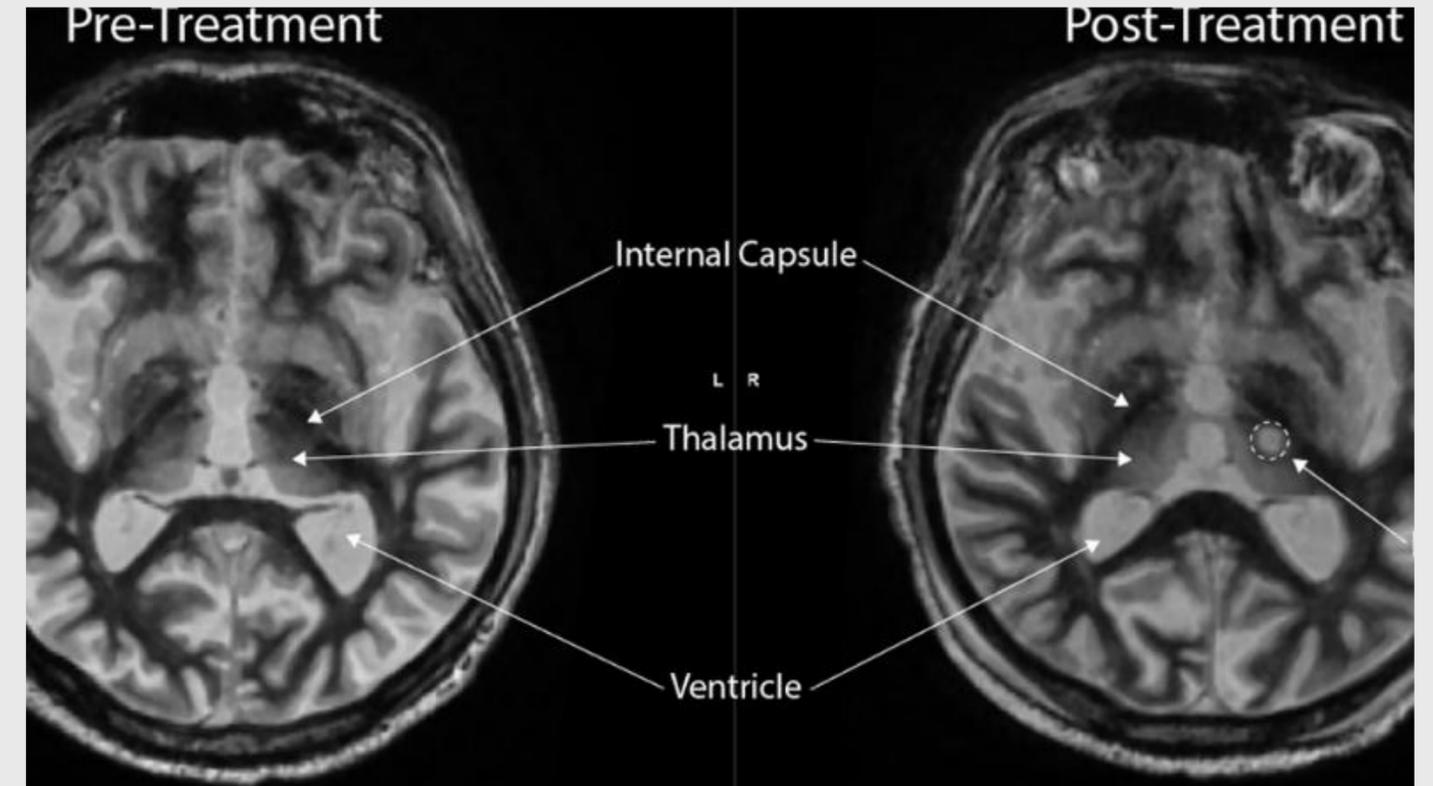


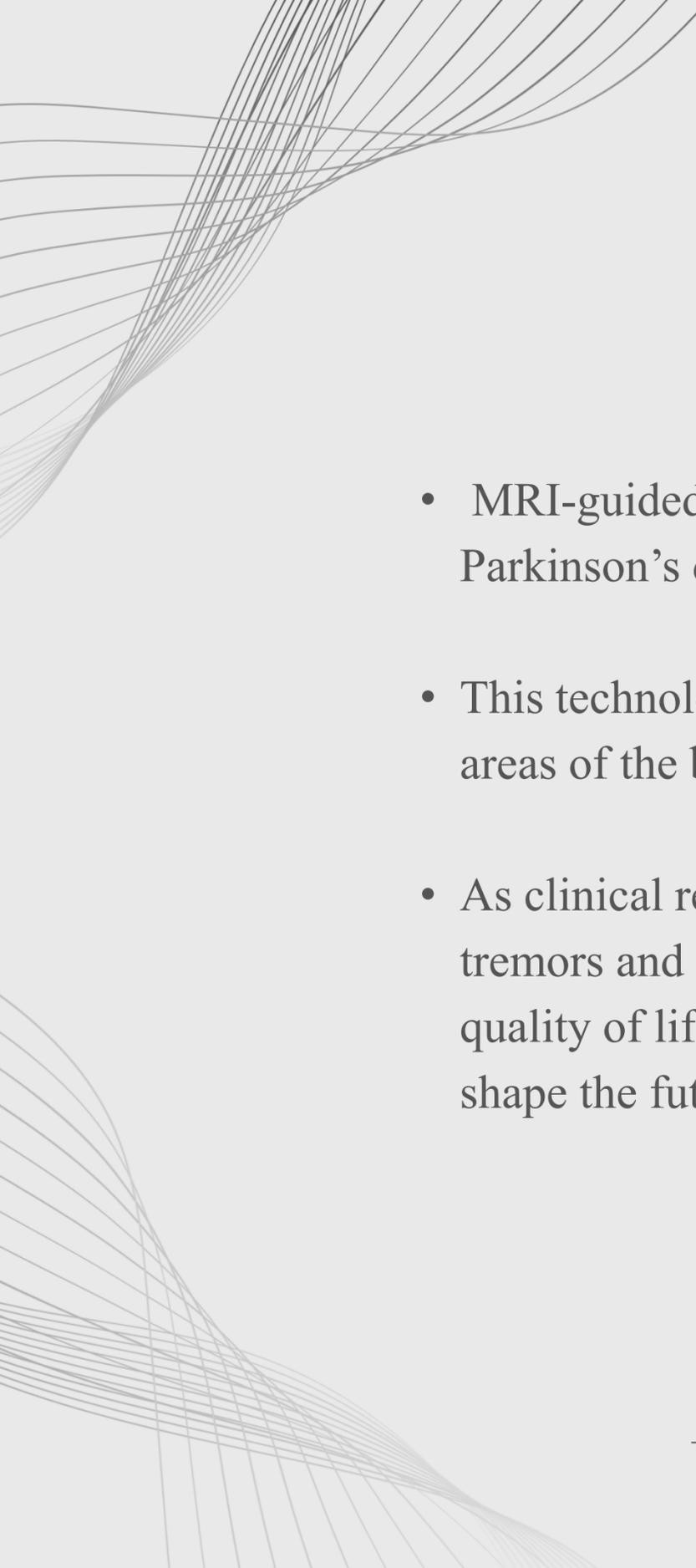
Figure 9. Pre-treatment and Post-treatment images of MRgFUS (Source: *Penn Medicine*, 2023).

Pre-treatment: baseline handwriting assessment (spiral, straight line, and a signature) performed before MRgFUS (Figure 8).

Post-treatment (lesion): following thalamic lesion creation, tremor oscillations were reduced, with corresponding improvements in handwriting legibility and motor precision (Figures 8 & 9).

FUTURE OF MRGFUS

- MR-guided focused ultrasound has demonstrated therapeutic potential not only in the treatment of essential tremor and Parkinson's disease, but also in bone metastases and targeted drug delivery. More effective cancer treatments have extended patient survival, increasing the need for therapies that address bone metastases (*Hurwitz et al.*, 2014).
- Chemotherapy drugs can be even more effective when assisted by MR-guided focused ultrasound, as the technique can more precisely target tumor cells for drug delivery (*Gasca et al.*, 2021).
- The blood-brain barrier (BBB), a protective layer that prevents substances in the bloodstream from entering the brain, normally blocks drugs from reaching brain tissue. However, MR-guided focused ultrasound combined with intravenous micro-bubbles injection can temporarily open the BBB, allowing chemotherapy drugs to reach tumors more effectively (*Gasca et al.*, 2021).
- Initial studies have demonstrated strong feedback, leading to larger clinical trials/research on targeted drug delivery. As technology continues to grow, MR-guided focus ultrasound is a key component of the future of non-invasive procedures (*Gasca et al.*, 2021).



CONCLUSION

- MRI-guided focused ultrasound is a safe and effective non-invasive treatment option for patients with Parkinson's disease and essential tremor.
- This technology combines real-time MRI with ultrasound waves to accurately target and treat affected areas of the brain, reducing the risk associated with traditional surgical intervention.
- As clinical research continues to advance, MRI-guided focused ultrasound has the potential to reduce tremors and serve as a noninvasive alternative to surgery. This technology not only improves the quality of life for patients with Parkinson's disease and essential tremor but also has the potential to shape the future of neurological therapies and drug delivery.

REFERENCES

Baylor College of Medicine. (n.d.). MR-Guided focused Ultrasound. Baylor College of Medicine.

<https://www.bcm.edu/healthcare/specialties/neurosurgery/mr-guided-focused-ultrasound>

Cleveland Clinic. (2025, July 9). Essential tremor. Cleveland Clinic.

<https://my.clevelandclinic.org/health/diseases/11886-essential-tremor>

Cleveland Clinic. (2025, September 22). Parkinson's Disease. Cleveland Clinic.

<https://my.clevelandclinic.org/health/diseases/8525-parkinsons-disease-an-overview>

Cleveland Clinic Medical. (2025, June 30). MR-Guided focused ultrasound for treatment of tremor. Cleveland Clinic.

<https://my.clevelandclinic.org/health/treatments/21087-mr-guided-focused-ultrasound-for-treatment-of-tremor#overview>

Duncan. (2020, November 12). Delight as NHS England approves funding for MRgFUS to treat essential tremor. National Tremor Foundation.

<https://tremor.org.uk/news/delight-as-nhs-england-approves-funding-for-mrgfus-to-treat-essential-tremor>

Student Host Hospital. (2025). MRgFUS equipment [Photograph].

Hayden, Holly. Personal Interview. (2025, October 28).

Jonker, B. (2021, April 5). Dr Benjamin Jonker | Tremor and MRI-Guided Focussed Ultrasound (MRGFUS). Central Neurosurgery.

<https://centralneurosurgery.com.au/tremor-and-mrgfus/>

REFERENCES

Marino, D. (2025, February 10). FOCUSED ULTRASOUND - Overcoming drug delivery challenges. Drug Development and Delivery. <https://drug-dev.com/focused-ultrasound-overcoming-drug-delivery-challenges/>

National Institute of Standards and Technology. (2025, May 27). How does an MRI machine work? | NIST. NIST. <https://www.nist.gov/how-do-you-measure-it/how-does-mri-machine-work>

Parkinson's Foundation. (2024, April 16). Non-invasive focused ultrasound helps alleviate Parkinson's symptoms. Parkinson's Foundation.

https://www.parkinson.org/blog/science-news/focused-ultrasound?utm_source=google&utm_medium=adgrant&utm_campaign=DSA&utm_term=&gad_source=1&gad_campaignid=10578592284&gbraid=0AAAAAD-w4kHRYdjgWcIxxLwICyQrePzSh&gclid=CjwKCAjwx-zHBhBhEiwA7Kjq69Q7AwfLaW7k9Xx4N6j6TgMBGxgzjhMLQdAWRRu1ZaDF39FDsaJh9xoCnqYQAvD_BwE

Penn Medicine. (2023, January 31). Focused ultrasound therapy for the treatment of medication refractory essential tremor. <https://www.pennmedicine.org/physicians-hub/clinical-briefing/focused-ultrasound-therapy-for-the-treatment-of-medication-refractory-essential-tremor>

Stanford Health Care. (n.d.). MR-Guided focused Ultrasound. Stanford Health Care. <https://stanfordhealthcare.org/medical-treatments/m/mr-guided-focused-ultrasound.html>

Thounlasenh, Kelley. Personal Interview. (2025, October 23).

Zindler, Bailes. (2025). Tyler Neurosurgical Associates.

<https://tylerneuro.com/our-services/brain-surgery/essential-tremor>



THANK YOU