C18 The Use of Magnetic Resonance Guided Focused Ultrasound (MRgFUS) for Treating Tremor -Dominant Parkinson's Disease

Objectives

Understand the modalities used in MRgFUS.

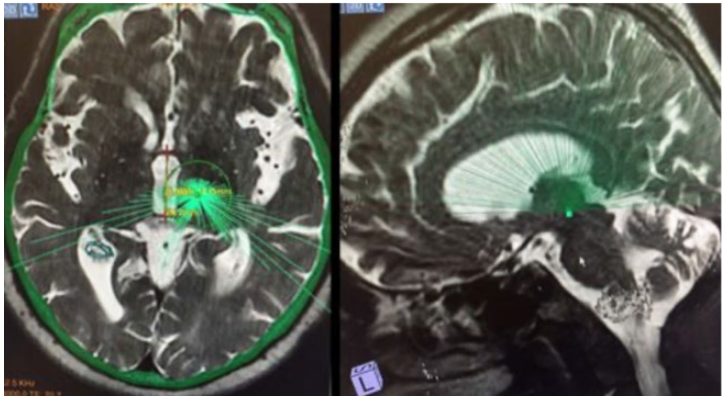
Define tremors and Parkinson’s disease.

Discuss the connection of modalities used in the treatment tremors.

Explain the process of MRgFUS.

Compare the benefits, risks, and contraindications for MRgFUS.

Introduction



Dr. Kaplitt First in New York to Use Focused Ultrasound for Essential Tremor. (2016, July 22). Weill Cornell Medicine Neurological Surgery. https://neurosurgery.weillcornell.org/in-the-news/dr-kaplitt-first-new-year-use-focused-ultrasound-essential-tremor

- Magnetic Resonance Imaging (MRI) is a medical imaging technique that uses radio and magnetic waves to produce three dimensional images of organs in the body.
- Ultrasound is another medical imaging technique using high frequency sound waves to produce live images of internal structures.
- Parkinson's disease is a degenerative brain disorder where neurons in the brain die, causing tremors. It has no cure but a wide variety of treatment options.
- MRgFUS aims to treat tremors by simultaneously utilizing MRI and ultrasound.
- Utilizing MRgFUS treatment can lead to better outcomes in treating tremor-dominant Parkinson's disease, however, the treatment is personalized and may not be beneficial for everyone.

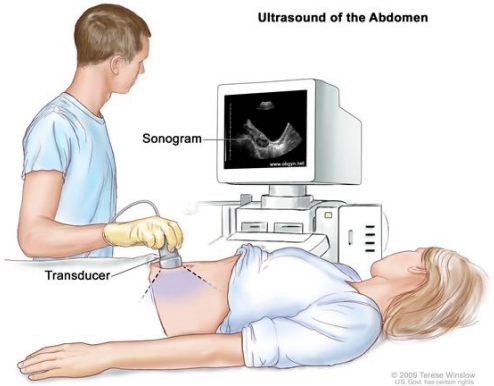
Magnetic Resonance Imaging (MRI)

- **MRI (Magnetic Resonance Imaging)** : Noninvasive technique using radio waves and magnetic fields to create 3D body images (*MRI*, (n.d.)).
- **MRI Machines** : Large, tube-shaped magnets that generate images by interacting with hydrogen atoms in the body (*MRI*, (n.d.)).
- **Focus on Soft Tissues** : MRI is ideal for imaging the brain, spinal cord, muscles, nerves, ligaments, and tendons, unlike X-rays or CT scans, which focus on bones.

Gateway Diagnostic Imaging. (2023, November 30). What should I expect during my MRI? https://www.gatewaydiagnostic.com/what-should-i-expect-during-my-mri/

Ultrasound (US)

- Ultrasound is a noninvasive imaging technique that uses high-intensity sound waves to create real-time images or videos of internal organs, such as blood vessels or other soft tissues.
- **During an ultrasound:**
  - A device called a transducer or probe is used.
  - A thin layer of gel is applied to the probe and moved across the area of interest on the patient's body.
  - The transducer facilitates the transmission of inaudible high-frequency ultrasound waves into internal structures or tissues (*Ultrasound*, 2024).
  - Next, the transducer reflects the waves off internal structures and converts the waves into electrical signals.
  - The computer then processes these signals and produces real-time images or videos.



U.S. Department of Health and Human Services. (n.d.). *Ultrasound*. National Institute of Biomedical Imaging and Bioengineering. https://www.nibib.nih.gov/science-education/science-topics/ultrasound

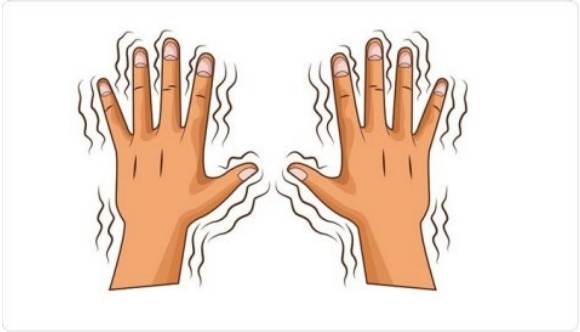
What is Parkinson's Disease?

- Parkinson’s disease is a brain disorder that worsens over time and affects the nervous system.
- In Parkinson’s disease, damage to the basal ganglia neurons disrupts movement control, leading to reduced dopamine production and movement issues (*Parkinson’s Disease: Causes, Symptoms, and Treatments*, 2022).
- Symptoms of Parkinson’s disease vary by person and progress gradually.

Kurnool, N.I. (n.d.). *What are the symptoms of parkinson’s disease. neurologist in kurnool. https://neurologistinkurnool.com /neurology-blod/f/what-are-the-symptoms-of-parkinsons-disease*

What are tremors?

- Tremors can be described as involuntary, rhythmic shaking, often starting in the hands, fingers, or occasionally legs/jaw.
- They are a direct result of the loss of dopamine-producing neurons, disrupting the brain's control of muscle movements.
- More specifically the area that is most related to tremors is the basal ganglia and its surrounding structures such as the thalamus and the substantia nigra.
  - This is because the basal ganglia is in charge of motor control as well as dopamine production (*Parkinson's Disease: Causes, Symptoms, and Treatments*, 2022).
- The cells within the basal ganglia may become impaired and/or die resulting in loss of motor control.



Snyder Lab. (n.d.). *2020 Stanford scientists uncover genetic basis of a common tremor disease*. https://med.stanford.edu/snyderlab/news/2020-stanford-scientists-uncover-genetic-basis-of-a-common-tremo.html

What is MRgFUS?

Carson, Katie. *Ultrasound's Role in Alzheimer's Treatment Research*. (2020, April 2). Imaging Technology News. https://www.itnonline.com/article/ultrasound%E2%80%99s-role-Alzheimer%E2%80%99s-treatment-research

- A noninvasive procedure for treating tremor-dominant Parkinson's disease if other medications or treatments are unsuccessful.
- MRgFUS uses MRI and ultrasound simultaneously to burn and destroy targeted unhealthy areas of the brain that produce tremors, typically the thalamus, without harming the surrounding tissues (*MR Guided Focused Ultrasound*, (n.d.)).

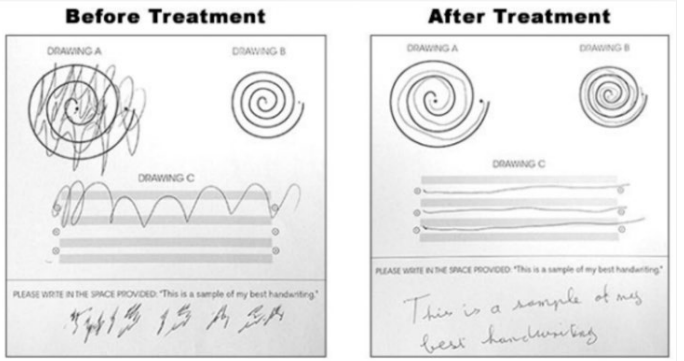
MRI:

- MRI is used to locate the area in the brain causing tremors.
- MRI monitors the patient's progress to know when to stop the treatment.

Ultrasound:

- Ultrasound beams converge to a single point in the brain, burning the tissue causing tremors.

Process of MRgFUS

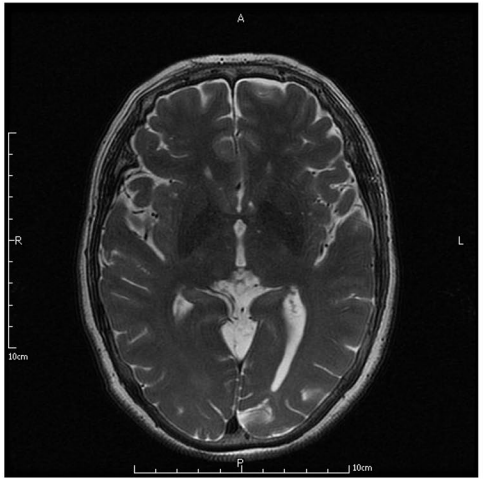


NEJM Study Shows MRgFUS Thalamotomy Aids Treatment of Essential Tremor. (2016, August 25). Stanford Medicine. https://med.stanford.edu/radiology/news/2016/mrgfus-thalamotomy-aids-treatment-of-essential-tremor.html

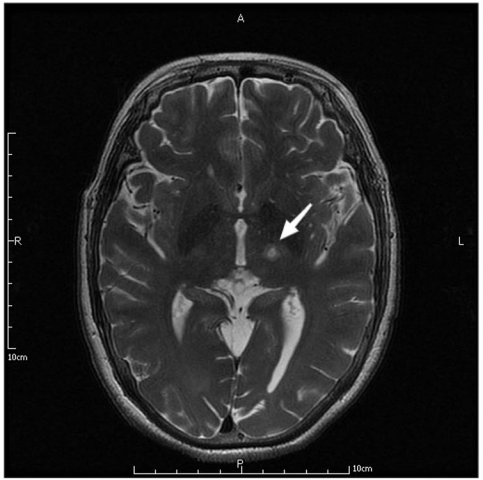
- The procedure lasts 3-4 hours.
- The patient wears a helmet (transducer) during the procedure which generates and focuses high intensity ultrasound waves.
- The transducer has about 1000 ultrasound beams, and each beam individually does nothing.
  - However, when all 1000 beams meet, a tiny, precise burn is created which allows the disruption of abnormal communication pathways in an area of the brain that controls voluntary movement and relieves a patients' symptoms (*MR-Guided Focused Ultrasound (MRgFUS) | Treatment for Parkinson's Disease & Essential Tremor,* (n.d.)).
- The patient is awake, and there is real-time feedback to see if the treatment is working immediately.
- Patients will be asked to draw, write, and repeat tasks during the treatment to see if ultrasound is relieving tremors (*MR-Guided Focused Ultrasound for Tremor*, 2019).

Average Brain vs Brain with Tremors

- In Image A, there is no presence of tremors, therefore an average brain is depicted.
- Image B shows a brain with an active tremor.
- Tremors cause muscles in the brain to flex, resulting in an increased demand for blood flow to those areas.
- This is what makes the visualization of tremors possible within MRI since the increased blood flow is detected.



(A)



(B)

Yin, C., Zong, R., Song, G., Zhou, J., Pan, L., & Li, X. (2022, August 2). *Comparison of motor scores between off and on states in tremor dominant parkinson's disease after Mrgfus treatment*. MDPI. https://www.mdpi.com/2077-0383/11/15/4502

Benefits & Risks

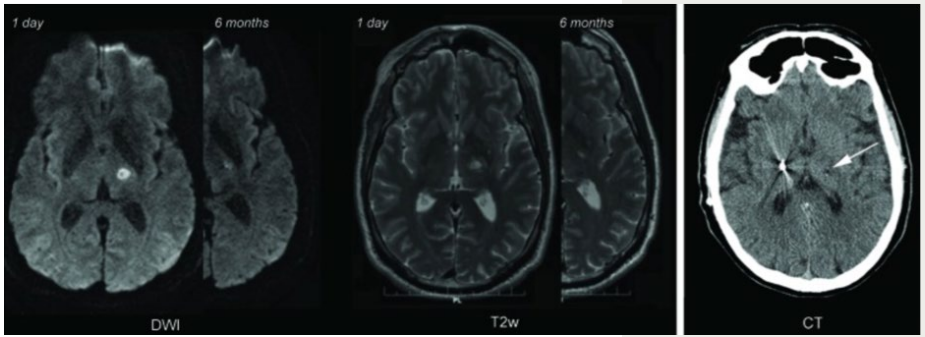
Benefits:

- There are no incisions, surgeries, or radiation needed for this treatment.
- It can be repeated with immediate results lessening tremors.
- Most patients can resume their regular activities within days to a week after the procedure (*MR-Guided Focused Ultrasound (MRgFUS) for Parkinson's Disease*, 2024).

Risks:

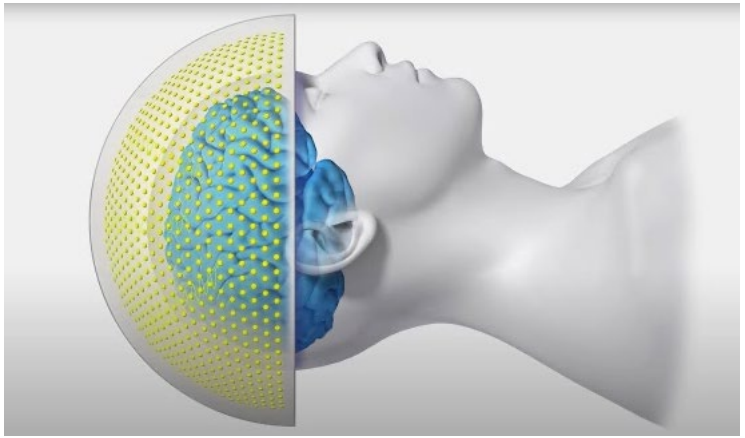
- The results of MRgFUS lessen with time since Parkinson's is a disease that worsens over time.
- Nausea and headaches may occur during the procedure.

Rohani, M., & Fasano, A. (2017, May 5). *Focused Ultrasound for Essential Tremor: Review of the Evidence and Discussion of Current Hurdles*. Tremor and Other Hyperkinetic Movements. http://tremorjournal.org/articles/10.5334/tohm.378



Contraindications

- Claustrophobia, or individuals who cannot lie in the same position for three or more hours.
- Metallic implants such as:
  - Pacemakers
  - Neurostimulators
  - Spine or bone fixation devices
  - Metal clips
  - Screws
- Extensive scarring on the scalp.
- Tumors inside the skull.
- Individuals who are on dialysis.
  - (*MR Guided Focused Ultrasound*, (n.d.)).



MR-Guided Focused Ultrasound (MRgFUS)| Treatment for Parkinson's Disease & Essential Tremor. (n.d.). Stanford Health Care. https://www.youtube.com/watch?v=3Bwq2YxD9eU

Conclusion

- Tremors induced by Parkinson’s continue to affect the individuals’ lives daily by reducing overall motor control.
- Each treatment is personalized and may not provide long lasting relief.
- MRgFUS is an innovative treatment to reduce tremors.
- MRgFUS utilizes MRI to locate the area in the brain causing tremors and ultrasound to target and destroy the tissue.
- MRgFUS offers an effective new way to manage tremors, significantly improving patients’ quality of life and ability to perform daily tasks.

References

Carson, Katie. *Ultrasound's Role in Alzheimer's Treatment Research*. (2020, April 2). Imaging Technology News. https://www.itnonline.com/article/ultrasound%E2%80%99s-role-Alzheimer%E2%80%99s-treatment-research

Cleveland Clinic. (2019, March 12). *MR-Guided Focused Ultrasound for Tremor*, https://my.clevelandclinic.org/health/treatments/21087-mr-guided-focused-ultrasound-for-treatment-of-tremor

Cleveland Clinic. (2024, May 1). *Ultrasound*. https://myclevelandclinic.org/health/diagnostics/4995-ultrasound

Dr. Kaplitt First in New York to Use Focused Ultrasound for Essential Tremor. (2016, July 22). Weill Cornell Medicine Neurological Surgery. https://neurosurgery.weillcornell.org/in-the-news/dr-kaplitt-first-new-york-use-focused-ultrasound-essential-tremor

Gateway Diagnostic Imaging. (2023, November 30). *What should I expect during my MRI?* https://www.gatewaydiagnostic.com/what-should-i-expect-during-my-mri/

Kurnool, N.I. (n.d.). *What are the symptoms of parkinson's disease. neurologist in kurnool. https://neurologistinkurnool.com /neurology-blog/f/what-are-the-symptoms-of-parkinsons-disease*

MR-Guided Focused Ultrasound (MRgFUS) for Parkinson's Disease. (2024, May 28). Precision Brain, Spine & Pain. https://www.precisionhealth.com.au/healthcare-services/ultrasound-brain/mr-guided-focused-ultrasound-mrgfus-for-parkinsons-disease/

MR-Guided Focused Ultrasound (MRgFUS) | Treatment for Parkinson's Disease & Essential Tremor. (n.d.). Stanford Health Care. https://www.youtube.com/watch?v=3Bwq2YxD9eU

References

MRI. (n.d.). Mayo Clinic. https://www.mayoclinic.org/tests-procedures/mri/about/pac-20384768

NEJM Study Shows MRgFUS Thalamotomy Aids Treatment of Essential Tremor. (2016, August 25). Stanford Medicine. https:med.stanford.edu/radiology/news/2016/mrgfus-thalamotomy-aids-treatment-of-essential-tremor.html

Parkinson's Disease: Causes, Symptoms, and Treatments. (2022, April 14). National Institute on Aging. https://www.nia.nih.gov/health/parkinsons-disease/parkinsons-disease-causes-symptoms-and-treatments

Rohani, M., & Fasano, A. (2017, May 5)*Focused Ultrasound for Essential Tremor: Review of the Evidence and Discussion of Current Hurdles*. Tremor and Other Hyperkinetic Movements.http://tremorjournal.org/articles/10.5334/tohm.378

Snyder Lab. (n.d.). *2020 Stanford scientists uncover genetic basis of a common tremor disease* https://med.stanford.edu/snyderlab/news/2020-stanford-scientists-uncover-genetic-basis-of-a-common-tremo.html

UCLA Health. (n.d.). *MR Guided Focused Ultrasound*. https://www.uclahealth.org/medical-services/neurosurgery/dbs/treatment-options/mr-guided-focused-ultrasound

U.S. Department of Health and Human Services. (n.d.).*Ultrasound*. National Institute of Biomedical Imaging and Bioengineering. https://www.nibib.nih.gov/science-education/science-topics/ultrasound

Yin, C., Zong, R., Song, G., Zhou, J., Pan, L., & Li, X. (2022, August 2)*Comparison of motor scores between off and on states in tremor-dominant parkinson's disease after Mrgfus treatment*. MDPI. https://www.mdpi.com/2077-0383/11/15/4502