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# **Ultrasound And Neurologist**

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## **(diagnosis & treatment & stimulus)**

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# Introduction

Ultrasound has become an indispensable tool in neurology, enabling non-invasive imaging, diagnostics, and stimulus for various neurological conditions.



Ultrasound is used in neurology to aid in the rehabilitation process of neuromuscular disorders. It helps in promoting muscle healing, improving blood circulation, and reducing muscle stiffness. Additionally, ultrasound therapy assists in restoring and enhancing neuromuscular function post-injury or neurological conditions.

## Overview of Ultrasound Technology

### Principles of Ultrasound

Ultrasound technology utilizes high-frequency sound waves to produce images of structures within the body. These sound waves are emitted from a transducer and then reflected back to create a detailed image, enabling the visualization of organs, tissues, and blood flow without the use of ionizing radiation.

## **Medical Applications**

Ultrasound has a wide range of medical applications, including diagnostic imaging, monitoring fetal development during pregnancy, guiding surgical procedures, and more. Its non-invasive nature and real-time imaging capabilities make it a valuable tool in modern healthcare.

## **Therapeutic Potential**

Beyond imaging, ultrasound technology is being explored for its therapeutic potential, such as breaking down kidney stones, promoting tissue healing, and stimulating neural activity. This opens up exciting possibilities for non-invasive treatments.

## **Technological Advancements**

Advancements in ultrasound technology have led to the development of portable and handheld devices, as well as enhanced imaging modalities such as 3D and 4D ultrasound. These advancements continue to expand the capabilities and accessibility of ultrasound in various fields.

# **Understanding the role of ultrasound in treatment**

## **Targeted Tissue Penetration**

Ultrasound waves can penetrate deep into the brain tissue with precision.

## Non-Invasive Approach

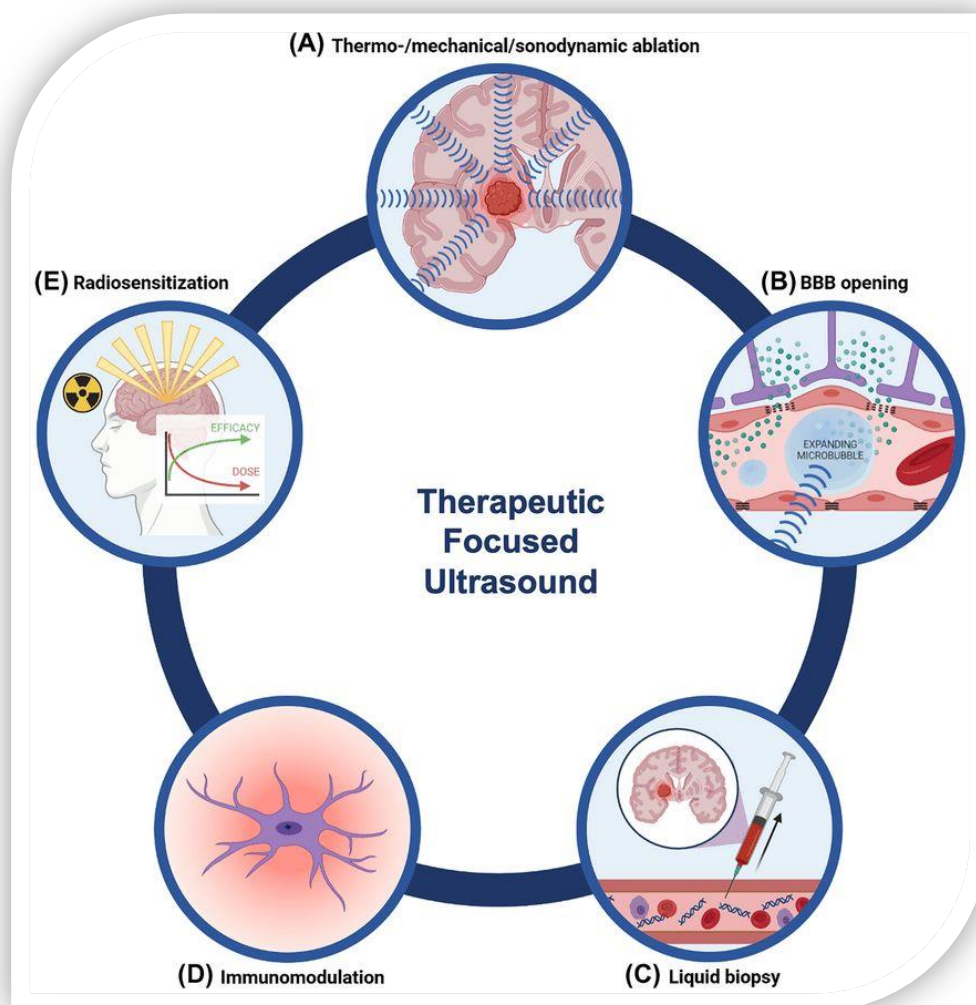
Ultrasound treatment is non-invasive, reducing the risk of complications associated with surgery.

## Stimulating Brain Activity

Ultrasound can stimulate neural activity, potentially aiding in cognitive functions.

## Potential for Drug Delivery

Ultrasound may assist in targeted delivery of therapeutic agents to specific brain regions.



# **Diagnosis of nervous system diseases**

Ultrasound has become an invaluable tool in the diagnosis of various medical conditions, offering non-invasive and real-time imaging of internal structures. By emitting high-frequency sound waves, ultrasound technology enables clinicians to visualize organs, tissues, and blood vessels with remarkable detail, aiding in the detection and monitoring of a wide range of health issues.

With its versatility and safety, ultrasound has revolutionized the field of medical imaging, providing clinicians with an essential diagnostic modality for conditions affecting the nervous system and beyond.

## **Basics of the nervous system**

The nervous system is a complex network of nerves and cells that carry messages to and from the brain and spinal cord to various parts of the body. It comprises two main parts: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS includes the brain and spinal cord, while the PNS consists of all the other nerves in the body. This intricate system is responsible for coordinating voluntary and involuntary actions and transmitting signals between different parts of the body.

The nervous system can be further divided into the somatic and autonomic nervous systems. The somatic nervous system controls voluntary movements, while

the autonomic nervous system regulates involuntary functions such as heart rate, digestion, and respiratory rate. Understanding the basics of the nervous system is crucial in comprehending the impact of various diseases and disorders on its functioning and how ultrasound can aid in diagnosing these conditions.

## **Role of ultrasound in diagnosing nervous system diseases**

**Non-invasive imaging:** Ultrasound provides a non-invasive imaging technique for visualizing the structures of the nervous system, including the brain, spinal cord, and peripheral nerves. This is crucial for diagnosing various neurological conditions without the need for surgical procedures.

**Real-time monitoring:** Ultrasound allows for real-time monitoring of blood flow in the brain and can help in identifying abnormalities such as aneurysms or vascular malformations, providing valuable insights for diagnosing neurological disorders.

**Guided procedures:** Ultrasound can be used to guide procedures such as nerve blocks or biopsies, enabling precise targeting of specific areas within the nervous system for diagnostic and therapeutic purposes .



# Common nervous system diseases diagnosed using ultrasound

**Stroke:** Ultrasound can be used to diagnose ischemic and hemorrhagic strokes by visualizing blood flow and identifying blockages or bleeding in the brain.

**Multiple Sclerosis (MS):** Through ultrasound imaging, doctors can detect lesions in the brain and spinal cord, aiding in the diagnosis and monitoring of MS.

**Peripheral Neuropathy:** Ultrasound helps in identifying nerve compressions, tumors, or injuries in the peripheral nerves, contributing to the diagnosis of peripheral neuropathy.

**Guillain-Barre Syndrome:** Ultrasound can assist in evaluating nerve thickness and detecting abnormalities in the peripheral nerves, supporting the diagnosis of Guillain-Barre Syndrome.

## Ultrasound techniques for diagnosing nervous system diseases

When it comes to diagnosing nervous system diseases, ultrasound techniques play a pivotal role in providing non-invasive and real-time imaging of the structural and functional aspects of the nervous system. Through the use of high-frequency sound waves, ultrasound can effectively visualize the brain, spinal cord, and peripheral nerves, aiding in the identification of any abnormalities or pathologies.

**These techniques include but are not limited to:**

- **Transcranial Doppler ultrasound for assessing blood flow in the brain**
- **Peripheral nerve ultrasound for detecting entrapment neuropathies and focal neuropathies**
- **Spinal ultrasound for evaluating spinal cord anomalies and abnormalities**

**The ability of ultrasound to provide dynamic imaging and assess the neural structures in real time adds significant value to the diagnostic process, allowing healthcare professionals to make timely and accurate assessments for better patient outcomes.**

## **Case studies : successful diagnosis of nervous system diseases using ultrasound.**

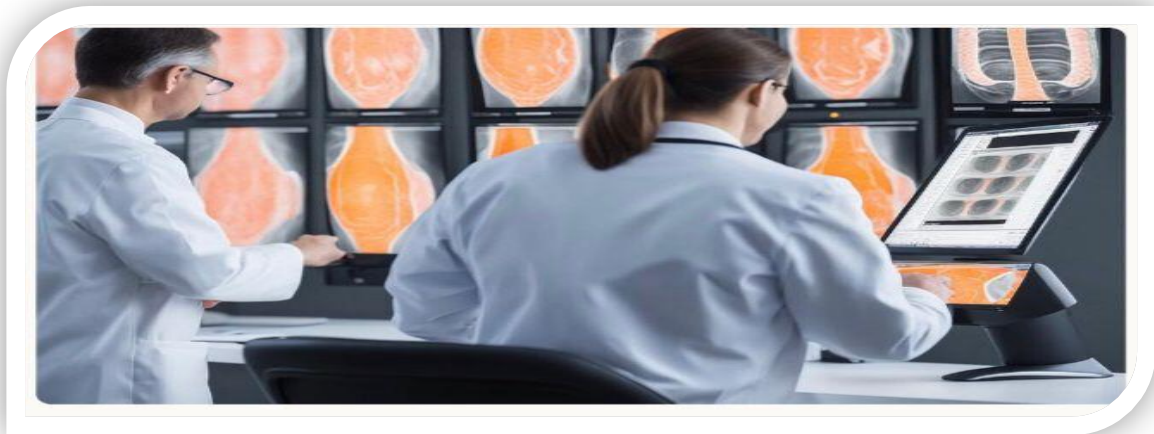
### **Brain scan with high resolution**





**An ultrasound machine is shown scanning the brain of a patient with a highly detailed cross- sectional view. The image captures the intricate structures of the brain, providing crucial insights for accurate diagnosis and treatment planning of nervous system diseases.**

## **Neurologist reviewing spine ultrasound**



**A neurologist is depicted examining a monitor displaying ultrasound images of the spine with focused concentration. The detailed imagery assists in identifying abnormalities or lesions in the spinal cord, aiding in the successful diagnosis of nervous system diseases.**

## **Nervous system diseases treatment using ultrasound**

**Ultrasound is gaining traction as a novel therapeutic approach in neurological disorders. This non-invasive technique utilizes targeted sound waves to stimulate**

or ablate neural tissue. By precisely modulating the intensity of the ultrasound waves, neurologists can achieve varying effects. Low-intensity ultrasound holds promise for enhancing neuronal activity and blood flow, while high-intensity focused ultrasound (HIFU) can create controlled lesions in specific brain regions.

This emerging technology is being actively investigated for its potential to treat a broad spectrum of neurological conditions, including essential tremor, Parkinson's disease, Alzheimer's disease, obsessive-compulsive disorder, and chronic pain. The significant advantages of ultrasound therapy lie in its non-invasive nature, minimal side effects, and unparalleled precision, offering a potentially transformative alternative to traditional medications or surgery for neurological care.

## Understanding ultrasound treatment

**Non-invasive:** Ultrasound treatment for Alzheimer's is a non-invasive procedure, meaning it does not require any incisions or entry into the body. It uses sound waves to reach the targeted areas in the brain without the need for surgical intervention.

**Targeted delivery:** The focused ultrasound waves can be precisely directed to specific regions of the brain, allowing for targeted treatment of the affected areas associated with Alzheimer's disease.

**Stimulation of brain cells:** Ultrasound treatment stimulates the activity of brain cells, promoting neuroplasticity and potentially reducing the impact of amyloid plaques and tau tangles, which are hallmarks of Alzheimer's.

## **Example of these treatments**

### **Treatment of Alzheimer's disease**

Alzheimer's disease is a progressive neurodegenerative disorder that primarily affects older adults, leading to a decline in cognitive function and memory loss. It is the most common cause of dementia, with symptoms ranging from mild forgetfulness to severe impairment in thinking, behavior, and the ability to perform everyday tasks. The disease significantly impacts not only the individuals diagnosed but also their families and caregivers. Understanding the complex pathology of Alzheimer's is crucial in developing effective treatments and care strategies. Research into potential treatments for Alzheimer's has led to various approaches, including the exploration of ultrasound therapy. This innovative treatment method shows promise in targeting amyloid plaques and tau tangles, two hallmark features of the disease. By utilizing focused ultrasound waves, researchers aim to disrupt these harmful accumulations in the brain, potentially slowing down the progression of the disease and improving cognitive function. The potential of ultrasound treatment offers hope for individuals affected by Alzheimer's and their loved ones.

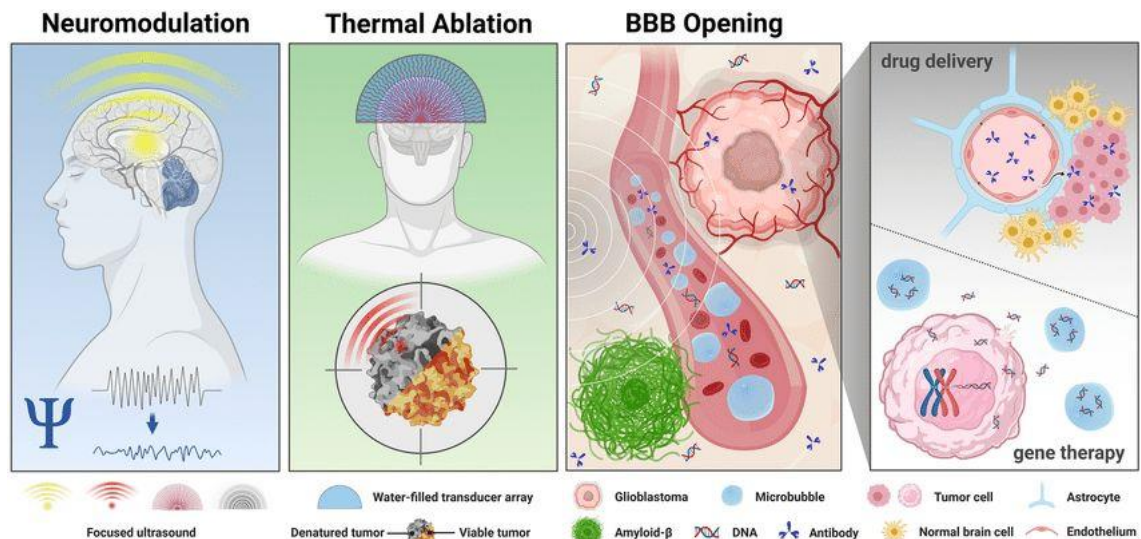
# How Ultrasound Works in the Brain

Ultrasound treatment for Alzheimer's involves the use of focused ultrasound waves to target specific areas in the brain. These waves are non-invasive and can penetrate the skull to reach the desired brain region without the need for surgical incisions. Once the ultrasound waves reach the brain, they can stimulate nerve cells, enhance the clearance of toxic proteins associated with Alzheimer's, and modulate neural activity.

This process, known as "sonication," involves the precise focusing of ultrasound beams to generate therapeutic effects within the brain. The ultrasound waves can also induce localized hyperthermia, which may aid in promoting the brain's natural healing processes and facilitating the delivery of therapeutic compounds to targeted brain areas.

In addition, ultrasound can potentially enhance the permeability of the blood-brain barrier, allowing for better uptake of drugs and other therapeutic agents. This approach holds promise in enabling more effective and targeted treatment for Alzheimer's, with the potential for fewer side effects than traditional interventions.

# The frequencies of ultrasound that used to treat Alzheimer's disease

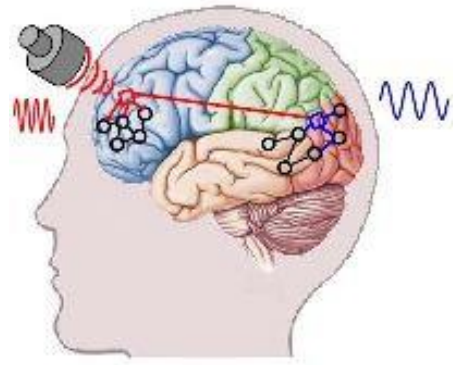


Ultrasound is emerging as a potential treatment for Alzheimer's disease, targeting specific brain regions with focused sound waves. Two main approaches are being investigated:

- \* Low-intensity focused ultrasound (LIFUS) employs frequencies below 3 MHz to potentially improve cognitive function and memory. This may be achieved by stimulating nerve growth and reducing the buildup of amyloid and tau proteins, hallmarks of Alzheimer's disease pathology.

- \* Focused ultrasound with microbubbles utilizes higher frequencies around 650 kHz or 220 kHz in conjunction with microbubble contrast agents. Microbubbles temporarily open

the blood-brain barrier, allowing medication delivery to the brain that wouldn't be possible otherwise.



While promising, this is a relatively new field of research. Most studies are in the preclinical stages, and more are needed to determine the safety and efficacy of ultrasound for Alzheimer's disease treatment.

## **Benefits of Ultrasound Treatment for Alzheimer's**

Ultrasound treatment for Alzheimer's offers several potential benefits in the management of the disease. One of the key advantages is its non-invasive nature, eliminating the need for surgical intervention. This approach reduces the risks associated with traditional surgical procedures and allows for targeted treatment without the use of medications. Additionally, ultrasound therapy has shown promise in enhancing the delivery of therapeutic agents to specific regions of the brain, potentially improving the efficacy of treatment.

Furthermore, ultrasound treatment may contribute to the reduction of amyloid plaques in the brain, a hallmark of Alzheimer's disease. By targeting these plaques, ultrasound therapy has the potential to slow down the progression of the disease and preserve



cognitive function in affected individuals. Moreover, the non-pharmacological nature of ultrasound treatment reduces the likelihood of drug-related side effects, making it a safer alternative for certain patients.

## **Stimulus brain nerves using ultrasound**

Ultrasound neuromodulation (UNM) is a burgeoning area of investigation in neurological therapeutics. It utilizes low-intensity ultrasound waves to target specific brain regions, modulating neuronal activity with the potential to revolutionize neurological treatment.

Compared to traditional neuromodulation techniques like deep brain stimulation (DBS) and transcranial magnetic stimulation (TMS), UNM offers significant advantages. It's non-invasive, eliminating the need for surgical electrode implantation in the brain. Additionally, UNM holds promise for more precise targeting of neural structures.

The precise mechanisms underlying UNM's therapeutic effects are still being elucidated, but several factors are thought to be involved:

- \* **Mechanical effects:** Ultrasound waves induce microscopic pressure changes within brain cells.

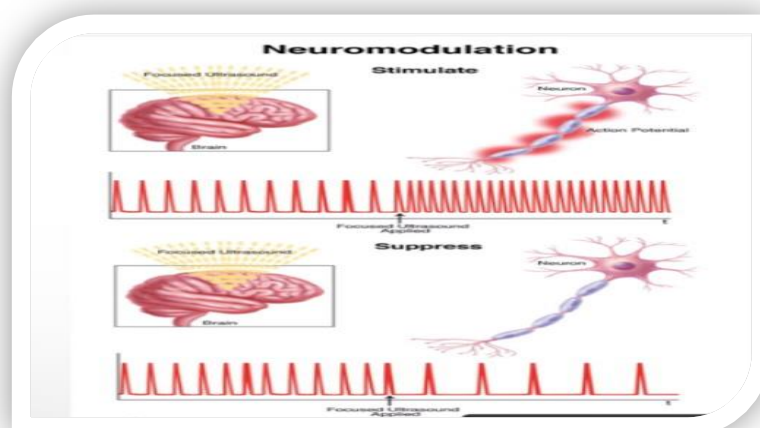
- \* **Thermal effects:** Ultrasound can generate heat, influencing neural activity.\* **Cavitation:** Microscopic cavitation bubbles entstehen (German for "come into

existence") within brain tissue, transiently altering cell membranes.

## Using Ultrasound to Stimulate Paralyzed Brain Nerves

In the fascinating realm of medical technology, innovative methods are being developed to tackle the challenges posed by paralysis. One such groundbreaking approach involves the use of ultrasound to stimulate the neural pathways within the brain that have been affected by paralysis. This cutting-edge technique holds immense promise for individuals who have been rendered immobile due to various neurological conditions, offering hope for increased mobility and enhanced quality of life.

By specifically targeting the affected nerves deep within the brain, ultrasound has the potential to reignite communication between the brain and the paralyzed muscles, opening up new possibilities for regaining movement and function. The application of ultrasound in this context represents a remarkable fusion of medical expertise and technological advancement, paving the way for transformative solutions in the field of neurorehabilitation.



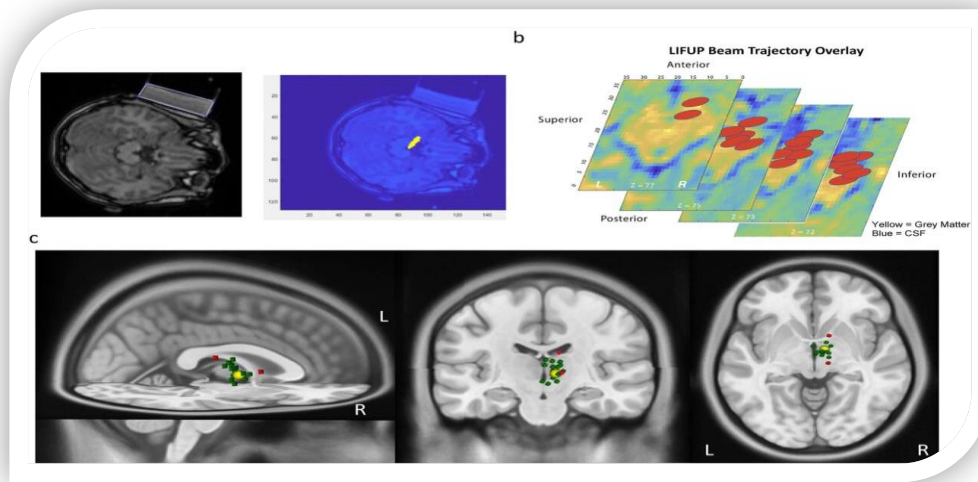
# **Understanding Paralysis and Its Impact on the Brain**

**Paralysis is a condition characterized by the loss of muscle function in part of your body. It can impact various aspects of daily life, from mobility and independence to emotional well-being. When it affects the brain, paralysis can have profound implications on cognitive functions and mental health. The brain's intricate network of nerves and signals plays a crucial role in coordinating movement and sensory perception. When paralysis occurs, these pathways are disrupted, leading to a cascade of challenges.**

**This disruption can result in not only physical limitations but also emotional and psychological effects. Patients may experience frustration, anxiety, and depression as they navigate the complexities of living with paralysis. Additionally, the impact on brain health and cognitive processes cannot be understated. The brain's ability to adapt and rewire itself, known as neuroplasticity, may be influenced by the presence of paralysis, further shaping the individual's experience.**

**It is important to delve deep into the specific nature of paralysis and its effects on the brain, as understanding these intricacies is crucial for developing effective interventions and treatments. By exploring the profound impact of paralysis on the brain, we can gain insights that may pave the way for innovative approaches to address this complex condition.**

# The Concept of Using Ultrasound to Stimulate Paralyzed Brain nerves



When traditional treatments for paralysis show limited effectiveness, researchers and medical professionals explore innovative solutions such as ultrasound stimulation to target paralyzed brain nerves. The concept involves using ultrasound waves to penetrate the skull and directly modulate the neural activity in the affected areas of the brain, aiming to restore motor function and improve overall quality of life for individuals with paralysis.

This groundbreaking approach harnesses the power of non-invasive ultrasound technology to deliver precise and targeted stimulation to the dormant neural pathways, potentially unlocking the potential for neural reorganization and regaining lost motor control. As this frontier of neuroscience unfolds, the exploration of ultrasound stimulation for paralysis holds promise for revolutionizing rehabilitation practices and offering hope to those affected by paralysis.

# Research and Studies on Ultrasound Stimulation for Paralysis

## Initial Research and Feasibility Studies

Early research into ultrasound stimulation for paralysis focused on assessing the feasibility of using this technology to activate paralyzed brain nerves. Scientists conducted studies to understand the potential of ultrasound waves to penetrate the skull and target specific areas of the brain associated with motor function.

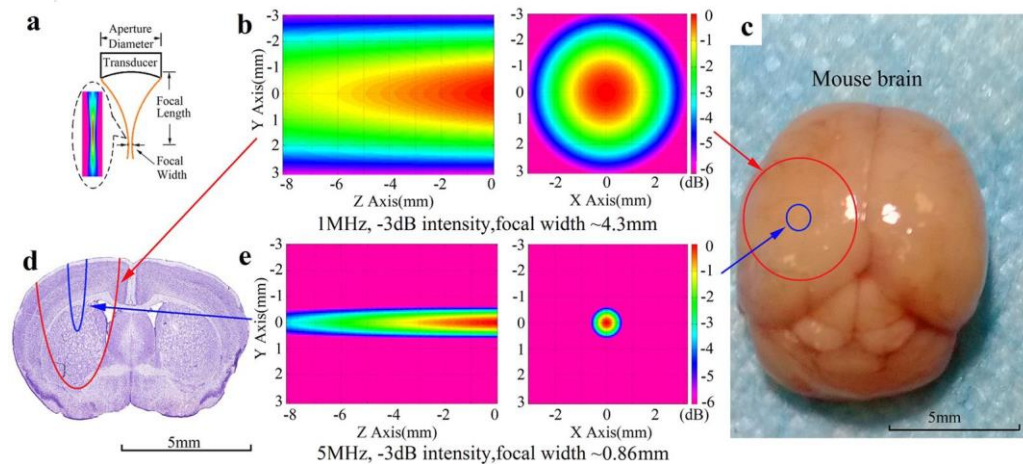
## Experimental Findings and Neural

Experimental studies delved into the neural responses observed during ultrasound stimulation in paralytic conditions. Researchers sought to identify the mechanisms by which ultrasound waves interact with the neuronal networks in the brain, aiming to elucidate the physiological

## Clinical Trials and Long-term Efficacy

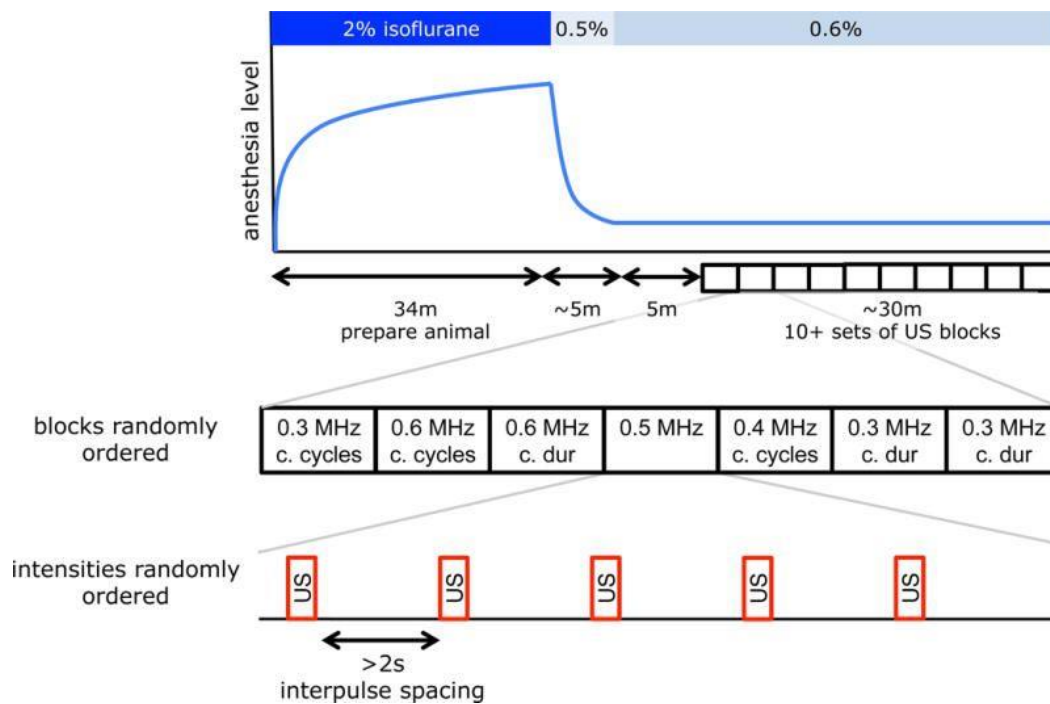
Clinical trials were initiated to evaluate the long-term efficacy of ultrasound stimulation for individuals living with paralysis. These trials involved monitoring and assessing the neurological improvements and functional outcomes in patients who received regular ultrasound therapy. The findings from these trials provided valuable evidence regarding the safety, effectiveness, and sustainability of ultrasound-based interventions for paralysis, paving the way for further advancements in this promising field.

# The frequencies of ultra sound that used to stimulate the parlayed nerves



The vast majority of published transcranial in vivo neuromodulation studies have been performed using relatively low ultrasound frequencies of less than 1 MHz. The use of such frequencies has generally been necessary because attenuation in tissues and the skull increases with frequency. Excessive attenuation is undesirable because it can both lead to potentially harmful heating effects in the attenuating tissues and reduce the ability to reach deeper structures. In addition, within the window of frequencies below 1 MHz, at least three in vivo studies have observed decreasing neuromodulation efficacy at the upper end of the frequency range tested that could not be attributed to heating effects.





**Experimental protocol. The sets labeled in this example are for Experiment A including sonications with constant number of cycles and constant duration. US = ultrasound.**

| Experiment | Center of frequency | Diameter (in.) | focusing  | US parameters   |
|------------|---------------------|----------------|-----------|---|
| Case1      | 0.5                 | 1              | planner   | <b>Frequency:</b><br>0.3, 0.4, 0.5, and 0.6 MHz<br><b>Duration:</b><br>80 ms CW and 40,000 cycles<br><b>Intensities:</b><br>4 intensities plus sham for each frequency, within a range from 0.1 to 3.5 W/cm <sup>2</sup> sppa after attenuation |
| Case2      | 1.0                 | 0.75           | 1.90" PTF | <b>Frequency:</b><br>0.6, 1.0, and 1.4 MHz<br><b>Duration:</b><br>80 ms CW<br><b>Intensities:</b><br>5 intensities plus sham for each frequency, within a range from 0.02 to 9.4 W/cm <sup>2</sup> sppa after attenuation                       |

|              |      |      |        |   |
|--------------|------|------|--------|---|
| <b>Case3</b> | 2.25 | 0.75 | 1" PTF | <p><b>Frequency:</b><br/>1.4, 1.9, 2.4, and 2.9 MHz</p> <p><b>Duration:</b><br/>80 ms CW</p> <p><b>Intensities:</b><br/>4 intensities plus sham for each frequency, within a range from 1.1 to 127 W/cm<sup>2</sup> sppa after attenuation</p>          |
| <b>Case4</b> | 2.25 | 0.75 | 1" PTF | <p><b>Frequency:</b><br/>1.4 and 2.9 MHz</p> <p><b>Duration:</b><br/>80 ms CW</p> <p><b>Intensities:</b><br/>at 1.4 MHz, 56.9 W/cm<sup>2</sup> sppa after attenuation plus sham; at 2.9 MHz, 90.7 W/cm<sup>2</sup> sppa after attenuation plus sham</p> |

# Benefits and potential applications of ultrasound stimulation

**Improved motor function:** Ultrasound stimulation has the potential to improve motor function in individuals with paralysis by aiding in the regeneration of nerve connections.

**Pain management:** Studies have shown that ultrasound stimulation can help in managing neuropathic pain associated with paralysis, providing a non-invasive alternative to traditional pain management techniques.

**Enhanced cognitive abilities:** Research suggests that ultrasound stimulation may have cognitive benefits for individuals with paralysis, such as improved memory and cognitive processing.

**Potential for rehabilitation:** Ultrasound stimulation could be used as part of rehabilitation programs for individuals with paralysis, helping in retraining neural pathways and restoring lost functions.

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