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## Information Sheet: MRI-guided focused ultrasound central lateral thalamotomy (MRgFUS CLT) for Neuropathic (neurogenic) Pain

Neuropathic (neurogenic) pain arises from damage to a nerve or injury to the spinal cord or brain. Causes include phantom pain following an amputation, nerve compression, polyneuropathy, plexus avulsion, pain associated with spinal cord injury, pain after a stroke (thalamic syndrome), trigeminal neuralgia, pain following a herpes infection (e.g., shingles), or pain after a herniated disc.

The disrupted signal transmission from the affected body regions leads to overactivity in the pain-processing area of the thalamus and surrounding brain areas. This overactivity results in the perception of constant pain or pain attacks. Our treatment aims to correct this overactivity in the thalamus, thereby relieving or eliminating the pain. This method is highly effective and does not interfere with normal brain functions. If necessary, neurogenic pain can also be treated on both sides of the body.

### Overview of MRgFUS CLT

**Magnetic Resonance-guided Focused Ultrasound Central Lateral Thalamotomy (MRgFUS CLT)** is an innovative and incisionless procedure developed to treat chronic, therapy-resistant neuropathic (neurogenic) pain. This type of pain can result from nerve injuries, spinal cord injuries, strokes, or conditions such as trigeminal neuralgia. MRgFUS CLT uses focused ultrasound energy, guided by MRI imaging, to create accurate and precise thermal lesions in a specific small region of the thalamus involved in pain processing, helping to reduce or eliminate pain without the need for incision or implants.

### How Does MRgFUS CLT Work?

1. **Targeted Thermal Ablation:** The central lateral thalamotomy (CLT) technique specifically targets the central lateral nucleus (CL) within the medial thalamus, which is a key area for pain signal processing. When this region is overactive due to neuropathic (neurogenic) pain, it can amplify pain signals unnecessarily, creating chronic pain.
2. **Focused Ultrasound Waves:** MRgFUS uses highly focused ultrasound waves that converge on the CL. This generates enough heat to create a small lesion, disrupting the pain signals sent from the thalamus to the cortex without impacting other critical areas of the brain. The thalamus can no longer amplify or sustain pain, providing relief.
3. **MRI Precision and Monitoring:** The entire process is monitored with real-time MRI, ensuring precise targeting and control of the ultrasound energy. This monitoring allows adjustments during the procedure to maintain accuracy and avoid damaging surrounding brain tissue. Precision is within 0.5 mm, offering a highly controlled, low-risk intervention.

### Benefits of MRgFUS CLT

- **Minimally Invasive:** Unlike traditional brain surgeries, MRgFUS requires no incisions or physical entry into the brain, reducing the risk of complications like infection or bleeding.
- **Procedure with Fast Recovery:** Most patients only require a short hospital stay and are often able to resume regular activities within days.



- **Pain Relief with Lasting Results:** Research and patient reports indicate that over 50% of patients experience at least 50% pain relief following MRgFUS CLT, and these results remain stable for years. On average, patients experience around 42% pain relief.
- **Reduced Medication Dependency:** Many patients report a reduction in the need for pain medications, including opioids, anticonvulsants, and antidepressants.
- **Improved Quality of Life:** Pain relief can enhance daily activities, emotional well-being, and overall quality of life for patients suffering from chronic neuropathic (neurogenic) pain.

### What to Expect During the Procedure

1. **Preparation and Setup:**
  - You will have your head stabilized in a specially designed stereotactic frame placed under local anesthesia.
  - An MRI scan will be used to pinpoint the exact target area within the thalamus.
2. **Ultrasound Application:**
  - Ultrasound energy is delivered through multiple sonications to create a small lesion in the targeted thalamic region.
  - The procedure is performed in stages, with gradual temperature increases, and the MRI thermometry monitors the treatment area.
  - You will remain awake to provide feedback on sensations, allowing the neurosurgical team to monitor any side-effects and assess the effectiveness of each sonication.
3. **Duration:**
  - The procedure typically lasts between 3-5 hours, though exact times may vary.
  - No general anesthesia or sedatives are needed, as patient feedback is essential throughout the treatment.
4. **After the Procedure:**
  - You will stay 1 up to 2 nights for observation and MRI confirmation of lesion placement.
  - Most patients are discharged the following day and can return to light activities soon afterward.

### Who is Eligible for MRgFUS CLT?

MRgFUS CLT may be suitable for patients with chronic, therapy-resistant neuropathic (neurogenic) pain. The criteria for this procedure typically include:

- **Duration and Resistance:** Chronic neuropathic (neurogenic) pain for more than (one-)two years that has not responded to at least one anticonvulsant and one antidepressant drug.
- **Pain Conditions:** Commonly treated pain types include:
  - Trigeminal neuralgia



- Pain after nerve injuries or nerve-related surgeries (e.g., postherpetic neuralgia, radiculopathy from herniated discs)
- Polyneuropathy
- Pain after spinal cord injury
- Pain following strokes, especially thalamic or cortical strokes
- **Assessment by a Specialist:** A comprehensive evaluation by a neurosurgeon and neurologist experienced in MRgFUS and functional neurosurgery will determine your suitability.

### Expected Results

- **Pain Relief:** Research on MRgFUS CLT for neuropathic (neurogenic) pain has shown significant pain reduction, with about 42% average relief at follow-up periods (some as long as 55 months). Over 50% of patients report ongoing relief of 50% or more at their last follow-up<sup>1-6</sup>.
- **Reduced Pain Intensity and Frequency:** The intensity of continuous pain and the frequency of pain attacks can decrease significantly. For example, studies report that pain attacks were reduced by 92% on average one year after treatment.
- **Quality of Life Improvements:** Patients often report improved ability to perform daily tasks and feel more satisfied with their quality of life after MRgFUS CLT.
- **Sustained Results:** Unlike other treatments that may lose efficacy, MRgFUS CLT has been shown to provide stable, long-term relief.

### Risks and Potential Side Effects

While MRgFUS CLT is designed to be incisionless and low-risk, it is essential to be aware of potential side effects, although they are rare:

- **Temporary Discomfort:** Patients may feel brief, mild discomfort during the ultrasound application but this is temporary and generally well-tolerated.
- **No Infection and very low Bleeding Risks:** The incisionless nature of MRgFUS CLT means there is no risk of infection. The bleeding risk is much lower compared to traditional brain surgeries (0 over >650 targets performed at Sonimodul in Solothurn).
- **Sensory Changes:** An unwanted extension of the CL-target has led in 2 cases over the last >10 years to a mild loss of sensation over a small area of skin in the face (in one, it was a numbness in the lip area).

### Preparing for MRgFUS CLT

We will conduct a comprehensive review of your medical history, symptoms, and previous treatments, a complete neurological examination as well as a quantitative electroencephalography (qEEG) to determine if MRgFUS CLT is right for you. A CT-scan will be performed and analyzed for skull density (Skull density ratio, SDR) to determine if MRgFUS treatment can be successfully apply on you. In order to plan the MRgFUS CLT targets, a stereotaxic MRI will be performed.

### Frequently Asked Questions

1. **Is the pain relief permanent?**



- While MRgFUS CLT has shown to provide stable, long-term pain relief in many patients, individual results may vary. In some cases, additional treatments may be necessary.
2. **Can MRgFUS be used to treat other conditions?**
- Yes, MRgFUS has also been used to treat essential tremor and Parkinson’s disease tremors.
3. **What are the advantages of MRgFUS CLT over other treatments?**
- MRgFUS CLT offers a non-invasive, highly accurate, and lower-risk alternative to deep brain stimulation or other forms of brain lesioning, with no need for implants or long recovery periods.
4. **Will I need to stop my current pain medications before the procedure?**
- All medications will be discussed before the procedure. Adjustments may be recommended for certain medications leading up to the treatment.
5. **How soon will I feel relief?**
- Some patients report feeling relief within days, while others may notice gradual improvements over weeks to months.

Historical background and results of the Central Lateral Thalamotomy<sup>1,4</sup>

Neuropathic (neurogenic) pain, or pain that originates from the nerves rather than from an injury or inflammation, is particularly challenging to treat. Many patients with this type of pain experience a constant or unpredictable “nerve pain” that does not improve with common painkillers. Often, the pain is so resistant to standard therapies that patients find themselves with limited treatment options.

Since the 1940s, neurosurgeons have explored treatments targeting specific areas of the brain to help manage this chronic pain. One area of focus is the *medial thalamus*, a part of the brain that plays a central role in processing and relaying pain signals. Early attempts involved procedures called thalamotomies, where small, controlled lesions were created in certain parts of the thalamus to reduce pain signals. While these early thalamotomies helped manage pain without causing major side effects, the relief they provided wasn’t always long-lasting.

In recent years, researchers have identified a more specific region within the thalamus called the *central lateral nucleus (CL)*, which appears to amplify pain signals in chronic cases. When this part of the thalamus becomes overactive, it can create a cycle of dysfunctional brain signaling known as *thalamocortical dysrhythmia*, which contributes to ongoing pain. By targeting this small area, it’s possible to interrupt these abnormal pain signals.

A promising technique called *MR-guided focused ultrasound (MRgFUS)* is now being used to precisely target the central lateral nucleus. This approach is very attractive because it’s incisionless—it uses focused ultrasound waves, guided by MRI, to reach and treat the central lateral thalamus without any surgical cuts or implants. This procedure allows for high accuracy (within 1 millimeter), reduces risks of bleeding and infection, and typically requires only a short hospital stay.

The study of Gallay et al. 2023<sup>4</sup> reviews the long-term results of MRgFUS thalamotomy performed in patients with chronic, therapy-resistant neuropathic (neurogenic) pain over an 11-year period. This study reviewed 63 MR-guided focused ultrasound (MRgFUS) thalamotomy procedures in 55 patients, all of whom had chronic, therapy-resistant neuropathic (neurogenic) pain. These patients



were followed for an average of about 4.5 years to see how well the treatment worked and to monitor any side effects.

On average, patients reported a **42% reduction in pain** that remained stable over time. More than half of the patients experienced at least **50% pain relief** following the procedure. **Pain attacks** (sudden intense bursts of pain) were greatly reduced. Patients reported a 92% decrease in the frequency of these attacks. Patients with **trigeminal neuralgia** (a type of severe facial pain) experienced especially good results, with an average of **76% pain relief**. Other conditions, such as pain after spinal cord injury, also showed notable improvements. **Quality of life** improved as well, with many patients reporting less anxiety, depression, and a greater ability to carry out daily activities. Some patients reduced or even stopped taking pain medications like opioids and antidepressants after the procedure.

The treatment was found to be safe, with no cases of bleeding or infection. Only one patient had a lasting side effect, experiencing some numbness in the upper lip. Temporary pain during the ultrasound treatment itself was common but manageable. Unlike invasive surgical treatments, MRgFUS avoids the need for cuts or implants, reducing the risk of complications and allowing for a shorter recovery time.

The results show that MRgFUS CLT is a very safe, incisionless, and effective long-term option for patients with chronic and therapy-resistant neuropathic (neurogenic) pain. By precisely targeting the central lateral nucleus in the thalamus, the procedure disrupts pain signals without affecting surrounding areas of the brain.

Importantly, this study found that pain relief from MRgFUS thalamotomy remained stable over the years, countering previous concerns that thalamotomies might lose effectiveness over time. Patients reported lasting reductions in pain intensity and frequency, improved mood and quality of life, and less reliance on pain medications.

In comparison to traditional brain surgeries or implanted devices, MRgFUS has several benefits. It's incisionless, lowers the risks associated with invasive procedures, and requires a shorter hospital stay. The findings support MRgFUS thalamotomy as a valuable option for patients with chronic neuropathic (neurogenic) pain who have exhausted other treatments, especially for those with conditions like trigeminal neuralgia where pain relief was particularly high. Overall, this study reinforces MRgFUS thalamotomy as a promising therapy for patients struggling with severe, persistent neuropathic (neurogenic) pain and highlights its potential as a long-lasting and safe pain relief solution.

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