# Laser interstitial thermotherapy

The use of laser interstitial thermal therapy (LITT) entered into the commercial era beginning in 2007 and has been used primarily in USA. Until now, two types of laser system, Visualase (Medtronic, Fridley, Minnesota, USA) and NeuroBlate (Monteris Medical, Plymouth, Minnesota, USA) are commercially available.

see Magnetic resonance image-guided laser interstitial thermal therapy.

The term laser thermotherapy is an acronym for Light Amplification by Stimulated Emission of Radiation, which first appeared as a term in 1959. Laser thermal therapy was clinically used for tissue ablation in 1966, based on the theory that the energy produced by laser light could achieve a high peak power through a ruby tip and could be absorbed by the surrounding tissue as heat <sup>1)</sup>.

However, using lasers for destroying neoplasms was still problematic because of the lack of a mechanism to monitor and control the energy  $^{2)}$ .

In 1983, as crystal-based neodymium-doped yttrium aluminum garnet (YAG laser) was introduced for tissue ablation, and some studies followed of laser ablation for brain tumors <sup>3) 4) 5) 6)</sup>.

Advances in technology and near real-time thermography have generated renewed interest in laser interstitial thermotherapy for the treatment of diseases of the brain and spine.

A critical technological milestone, magnetic resonance (MR) thermography, was introduced in 1994 - this could monitor the extent of ablation and tissue damage <sup>7)</sup>.

Essentially, the use of laser light allows the deposition of a precise amount of energy to a defined area at the tip of a fiber. The energy transmitted by the laser fiber is absorbed by tissues surrounding the tip and converted into heat. At temperatures between 55°C and 95°C, photocoagulation occurs, leading to rapid, irreversible tissue damage. Early on, the technique gained traction in the treatment of hepatic tumors and varicose veins, but the inability to monitor tissue damage and to protect eloquent structures initially hampered its use in neurosurgery. With the introduction of magnetic resonance thermography, which harnesses the temperature dependence of the proton resonance frequency to generate an accurate real-time map of tissue temperature, the treatment of deep-seated lesions in critical areas became feasible.

In the early 2000s, small studies by Schwarzmaier, Leonardi, and others started to show encouraging results for the treatment of recurrent glioblastomas, with survival exceeding what is typically seen with the current standard of care. In 2007, the first commercially available LITT system gained US Food and Drug Administration approval, and the popularity of the technique has grown steadily.

LITT has a number of unique features that make it of particular use in <u>neurooncology</u> and led to rather rapid adaptation in the field. Because only a small stab incision is used and closure consists of a single stitch, the risk of wound complications is negligible, and adjuvant therapy can be initiated Last update: 2024/06/07 02:56

almost immediately after surgery. This is of great theoretical benefit in the treatment of rapidly growing tumors such as glioblastomas. Furthermore, it avoids the significant risk of wound complications with reoperations on irradiated scalp. Most patients can be discharged home with minimal pain the day after surgery, and some institutions have shifted away from monitoring all patients in the intensive care unit postoperatively. In addition, there is mounting evidence that LITT interrupts the blood brain barrier, and studies investigating whether it can be used to enhance chemotherapy delivery are underway.

LITT is uniquely suited for the treatment of deep-seated intracranial metastases that have failed stereotactic radiosurgery because there is essentially no other safe and effective treatment available. This is becoming increasingly relevant as our methods of treating systemic cancer are expanding, in many cases allowing long-term survival when intracranial disease can also be controlled. LITT is also useful for focally recurrent glioblastoma, with several studies showing robust improvement in survival. Increasingly, the technique is being used for Thalamic high grade glioma, insula, or corpus callosum, which have generally been considered inoperable by most. Current treatment options for these tumors are limited and outcomes are poor, but early studies are showing that, with LITT, survival in select cases approaches the results seen with maximal safe open resection of noneloquent glioblastomas.

#### Laser interstitial thermotherapy in epilepsy surgery

#### see Laser interstitial thermotherapy in epilepsy surgery.

LITT has also been investigated as an alternative to separation surgery for spinal epidural metastases, with early results showing a reduction in tumor size and encouraging improvement in pain and functional status.

## Types

see Magnetic resonance image-guided laser interstitial thermal therapy

Laser interstitial thermotherapy (LITT), sometimes referred to as stereotactic laser ablation or SLA, is a minimally invasive surgery approach that uses thermal energy delivered by a laser to ablate tissue.

Advances in technology and near real-time thermography have generated renewed interest in this technology for the treatment of diseases of the brain and spine.

Several authors report technical adjuncts for improving the precision and speed of LITT using customized 3D printed frame as well as robot-assisted guidance for LITT.

Other groups have focused on assessing the safety of LITT procedures performed in a conventional operating room compared to the intraoperative MRI suite, and utilizing diffusion tensor imaging of the corticospinal tract to predict postoperative motor deficits.

Clinically oriented series include reports of LITT for rare lesions such as hypothalamic harmartomas, subependymal giant cell astrocytomas, and hypothalamic and intraventricular lesions often associated with epilepsy.

A multicenter review of LITT for brain metastases that recur after stereotactic radiosurgery and a

comparison of LITT for newly diagnosed and recurrent glioblastomas (Glioblastomas) are also presented.

Two groups describe the outcomes after efforts to minimize complications associated with post-LITT cerebral edema of large Glioblastomas by combining LITT with minimally invasive craniotomies<sup>8)</sup>.

# Methods

Two methods for intra-operative control of the laser induced lesions are:

Computer-controlled power delivery, using a thermocouple that is positioned interstitially at the periphery of the tumour to maintain the desired temperature at that point

MRI, to visualise the extent of the thermal lesions induced by ILTT. The results show that ILTT using a Nd: YAG laser is easy and relatively effective in the treatment of small deep-seated brain tumours with minimal risk and complications<sup>9</sup>.

It is feasible to visualize interstitial laser-induced lesions in the brain by ultrasonography. This method is safe and simple and may be helpful in future applications of interstitial thermotherapy in brain tissue  $^{10}$ .

The results of our MR follow-up studies showed that post-LITT, laser-induced lesions will shrink exponentially after an initial expansion without any pseudo cystic effects <sup>11</sup>.

## Stereotactic guided laser induced thermotherapy

Stereotactic guided laser interstitial thermotherapy (SLITT) represents a minimal invasive method to produce necrosis in cerebral tumor tissue by local heating. The dose/response relationship relies on experimental studies and few clinical data performed in high field MR systems. A better understanding of the energy-dose/tissue response in human brain tumors is important to optimize this treatment modality.

Twenty-four patients with gliomas were treated with SLITT, with a total of 30 laser procedures performed. Under local anesthesia 600 microns laser-fibers were inserted by stereotactic-guided technique into the center of the tumor. In a low field open MR system (0.2 T) the denaturation of the tumor using a neodymium YAG laser (1064 nm) was monitored by 3D-turbo FLASH T1-weighted sequences. Laser energy was applied in steps of 400 to 1200 Joules. Development of necrosis at a mean total energy dose of 2979 Joules could be monitored in all procedures. Two different thermal lesion architectures were observed. First signal changes were monitored after a mean of 1108 Joules and 1393 Joules, respectively. Mean max. total lesion size was 21.2 mm. The higher the total energy the larger was the thermolesion, but no linear relationship could be seen. Tumor tissue response showed no dependency on tumor grading. Monitoring of stereotactic guided laser-induced thermolesions in the low-power MR OPEN is feasible and safe. Although lesion size basically is energy dependent, it should be applied individually, since the thermal response in brain tumors varies due to different optical properties, even in the same tumor gradings <sup>12</sup>.

Is a feasible alternative for the treatment of symptomatic regrowing metastatic lesions after radiosurgery. The procedure carries minimal morbidity and, in this small series, shows some effectiveness in the symptomatic relief of edema and neurological symptoms paralleled by

radiographic lesional control. Further studies are necessary to elucidate the safety of this technology <sup>13)</sup>.

## **Case series**

#### 2017

In the Department of Neurosurgery, Washington University School of Medicine in St. Louis, Missouri, Seventeen patients underwent 23 procedures using the ROSA system. A total of 87 electroencephalography electrodes were placed, with 13% deviating more than 3 mm from target. Six patients underwent stereotactic needle biopsy, and 9 underwent laser interstitial thermotherapy (LITT). One patient who underwent LITT required a subsequent craniotomy for tumor resection. Another patient experienced an asymptomatic extraaxial hematoma that spontaneously resolved. No patient suffered neurological complications during follow-up. Follow-up from the last procedure averaged 180 days in epilepsy patients and 309 days in oncology patients.

The precision, ease of use, and versatility of the ROSA system make it well suited for pediatric neurosurgical practice. Further work, including long-term analysis of results and cost-effectiveness, will help determine the utility of this system and if its applications can be expanded <sup>14</sup>.

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