

Lighting the Future of Neuro-Oncology: Laser Interstitial Thermal Therapy for Brain Tumours

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Abstract

Laser interstitial thermal therapy (LITT) is an image-guided neurosurgical technique that destroys pathological brain tissue through controlled thermal energy delivered via stereotactic catheter placement. It is primarily used for deep, recurrent, or unsuitable intracranial lesions, including high-grade gliomas, metastatic deposits, and treatment-related necrosis. This review aims to summarize the current evidence regarding the indications, clinical outcomes, procedural considerations, and complications of Laser Interstitial Thermal Therapy in the management of brain tumours.

Keywords: Laser interstitial thermal therapy, minimally invasive neurosurgery, brain tumour management, MRI-guided laser ablation, glioblastoma management, thermal coagulation.

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Introduction

Brain tumours remain among the most challenging conditions in neuro-oncology, specifically because of their complex anatomy, infiltrative nature, and proximity to important brain regions. Compared with conventional management surgical techniques such as open craniotomy, chemotherapy, radiotherapy, and stereotactic radiosurgery, Laser Interstitial Thermal Therapy (LITT), also known as Stereotactic Laser Ablation (SLA), is an effective, minimally invasive neurosurgical alternative.¹

This procedure comprises the stereotactic delivery of non-ionizing laser energy to the target tissue, wherein the absorbed photonic energy is converted to thermal energy, leading to hyperthermia, coagulative necrosis, and thermal ablation of the cellular structure around the site of irradiation. Irrespective of tumour histology, most patients undergoing LITT are discharged within 12–48 hours and

resume systemic treatment and radiotherapy shortly thereafter.² However, despite promising clinical results, issues with surgical complications, patient selection, long-term efficacy, cost, and the scarcity of specialized tools and knowledge persist.

Literature Review

Laser interstitial thermal therapy (LITT) is a minimally invasive, MRI-guided technique that delivers targeted thermal ablation to intracranial tumours through a stereotactically placed laser probe. Its primary indication in tumour management is for deep-seated, recurrent, or surgically high-risk lesions, including recurrence, brain metastases progressing after stereotactic radiosurgery (SRS), and radiation necrosis (RN).

The National Comprehensive Cancer Network (2026) lists MRI-guided LITT as a category 2B option, while the 2025 CNS guidelines provide Level III recommendations for LITT in patients who are poor surgical candidates, including those with relapsed brain metastases, radiation necrosis, glioblastomas, and other high-grade gliomas.^{3,4} Compared with open craniotomy, LITT offers shorter hospital stays, reduced wound morbidity, and faster return to systemic therapy, making it particularly attractive for paediatric CNS tumours and selected dural-based tumours such as meningiomas or solitary fibrous tumour with recurrence after prior surgery or radiation and poor candidacy for re-resection.

De Groot et al. demonstrated that Laser Interstitial Thermal Therapy (LITT) achieves meaningful local tumour control with relatively low procedural morbidity in patients with recurrent glioblastoma.⁵ Findings from the prospective multicenter LAANTERN registry further supported its efficacy, reporting 6-month and 12-month overall survival rates of 92% and 42%, respectively. In addition, pooled analyses showed a 6-month progression-free survival rate of approximately 25%, indicating favourable short-term disease control in selected patients.⁶ These results highlight the growing role of LITT as a minimally invasive alternative for recurrent and surgically challenging glioblastomas, although larger prospective studies are still needed to establish standardized treatment guidelines.

For brain metastases after SRS failure, data from a

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multicentric prospective study show that combination therapy with LITT followed by repeat SRS provides markedly longer local control than either treatment alone, extending median time to progression to nearly 30 months versus 7.5 months with LITT alone and 3.7 months with repeat SRS alone,⁷ making the combined approach far superior in treatment. A single surgeon conducted an exploratory cohort analysis of 313 patients from 2013 to 2023 undergoing LITT for various intracranial lesions, reporting a mean overall survival of 38.1 months, with greater ablation (>100%) predicting longer survival in metastases and glioblastoma.⁸

Over the past decade, MRI-guided laser interstitial thermal therapy (LITT) has gained an expanding role in neuro-oncology, particularly for eloquent or surgically inaccessible lesions. Current indications include recurrent glioblastoma, metastatic tumours progressing after stereotactic radiosurgery (SRS), radiation necrosis, and selected newly diagnosed gliomas in patients who are poor candidates for open craniotomy. Due to its minimally invasive nature, LITT is especially useful in elderly or medically frail patients with significant comorbidities. Careful preoperative preparation and postoperative care remain essential.

In paediatric neuro-oncology, LITT has emerged as a promising option for lesions located in challenging regions such as the thalamus, hypothalamus, and deep temporal structures. Paediatric applications include low-grade gliomas, hypothalamic hamartomas, and recurrent tumours where repeated craniotomies may increase morbidity.⁹ found that LITT ablation was safe and effective in 35 children with challenging brain lesions, with 67.9% of patients seizure-free and 88% without tumour recurrence. Minimally invasive approaches may be particularly beneficial in children because conventional surgery and radiation can contribute to long-term neurocognitive and developmental sequelae.

LITT offers the additional advantage of immediate cytoreduction and tissue acquisition for histopathological diagnosis. This is particularly valuable in recurrent enhancing lesions after SRS, where distinguishing tumour recurrence from radiation necrosis using imaging alone can be difficult. Histological confirmation obtained during LITT may directly guide subsequent oncologic management. Grabowski et al. reported improved local control when LITT is combined with repeat SRS for previously irradiated metastatic lesions.⁷

Despite these benefits, LITT remains associated with complications and limitations. Meta-analysis by Alkazemi et al.⁹ has reported overall complication rates approaching

30%, with postoperative cerebral oedema, focal neurological deficits, haemorrhage, and seizures among the most commonly encountered adverse events. In addition, the absence of large randomized controlled trials, limited long-term survival data, reduced efficacy in large-volume tumours, high equipment costs, restricted availability in specialized centers, and the inability to provide immediate decompression continue to limit broader clinical application.¹¹

Conclusion

LITT has emerged as a promising minimally invasive treatment modality for recurrent and deep-seated brain tumours, particularly in patients who are poor candidates for open surgery. Challenges such as post-operative complications, high procedural costs, and restricted accessibility in LMICs continue to limit its widespread adoption. Future large-scale prospective studies and technological advancements are essential to establish standardized protocols and further define the long-term efficacy and safety of LITT in brain tumour management.

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