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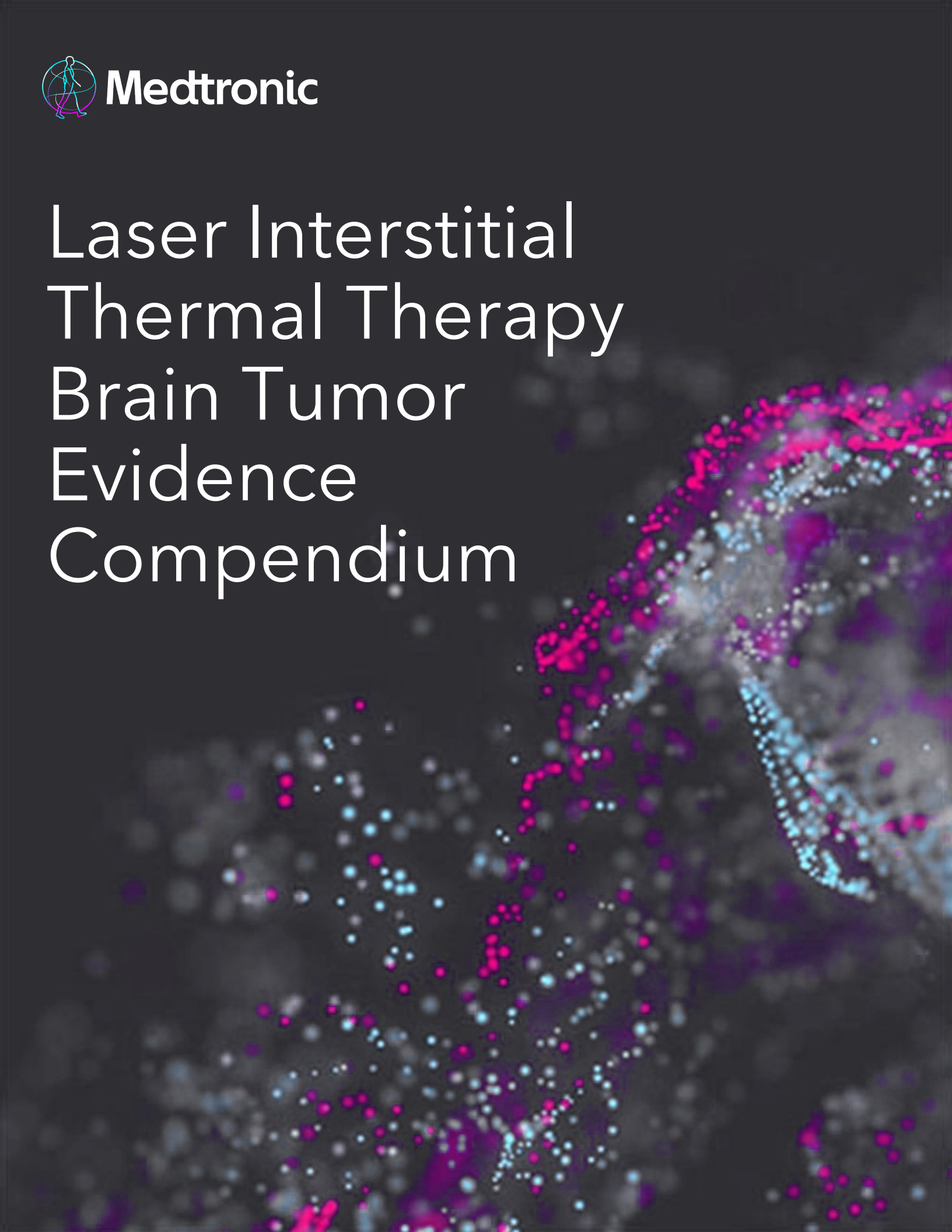
Laser Interstitial Thermal Therapy Brain Tumor Evidence Compendium



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Introduction (I/II)

The Visualase™ V2 MRI-Guided Laser Ablation System is a neurosurgical tool and is indicated for use to ablate, necrotize, or coagulate intracranial soft tissue including brain structures (for example, brain tumor, radiation necrosis, and epileptic foci as identified by non-invasive and invasive neurodiagnostic testing, including imaging) through interstitial irradiation or thermal therapy in pediatrics and adults with 980nm lasers. The intended patients are adults and pediatric patients from the age of 2 years and older.

In 2021, Barnett et al published a position statement on the use of laser interstitial thermal therapy (LITT) for brain tumors and radiation necrosis on behalf of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons.[1] They concluded:

LITT is an appealing option because it offers a method of minimally invasive, targeted thermal ablation of a lesion with minimal damage to healthy tissue. There is a growing body of evidence to demonstrate that LITT is an effective and well tolerated cytoreductive option for treatment of nGBM [newly diagnosed glioblastoma], rGBM [recurrent glioblastoma], and Mets/rMets [metastases/recurrent metastases]. Intracranial LITT is also an effective option for addressing radiation necrosis with an overall reduction in steroid dependence for these patients. Especially in instances where the therapeutic window is narrowed such that craniotomy is not a viable option, LITT can play an important role in treatment for glioma or metastatic brain cancer. A multidisciplinary approach remains the cornerstone in the treatment of patients with brain tumors or radiation necrosis. It is important that physicians have discretion to exercise their clinical judgement when evaluating the most appropriate option for their patients' individual treatment plan.

Introduction (II/II)

This clinical evidence summary includes key studies that evaluate the use of LITT for the ablation of brain lesions. LITT is a minimally invasive procedure that may be better tolerated than open resection for patients with brain tumors.[2] The summaries on the following pages address outcomes such as length of hospital stay, extent of tumor ablation, adverse events, and other procedural details that are important to take into account when considering LITT for patients with brain tumors.

Pooled analyses with ≥ 10 studies, publications focused on newly diagnosed tumor with ≥ 20 patients/procedures, studies on recurrent or metastatic tumor with ≥ 25 patients/procedures, and mixed population studies with ≥ 50 patients/procedures and published in 2024 or earlier were included in this compendium. Mixed population could be due to tumor type (newly diagnosed and metastatic/recurrent), indication (brain tumor and radiation necrosis or other brain lesions), or patient population (adult and pediatric).

Executive summary

Study types
(n, publications)

- Retrospective studies (15)
- Pooled Analyses (7)
- Prospective studies (3)

Lesion types
(n, publications)

- Newly diagnosed primary tumor (17)
- Recurrent primary tumor (11)
- Metastatic tumor (10)
- Radiation necrosis (8)

Key outcomes
(n, publications)

- Complications (24)
- Length of hospital stay (18)
- Procedure time (13)
- Extent of ablation (12)
- Treatment after LITT (9)
- Functional status before and after LITT (7)
- 30-day readmission (4)

Acronyms and abbreviations

Acronyms and abbreviations are defined in the table below, as well as upon first use in the text.

Acronyms and abbreviations			
AE	Adverse Event	**Mm**	Millimeter(s)
BM	Brain Metastases	**Mo(s)**	Months
CCI	Charlson Comorbidity Index	**ndGBM**	Newly Diagnosed Glioblastoma
CI	Confidence Interval	**N**	Number
cm^3	Cubic centimeters	**N/A**	Not Applicable
CNS	Central Nervous System	**NS**	Not Statistically Significant
EOA	Extent of Ablation	**NSCLC**	Non-small Cell Lung Cancer
EQ-ED-3L	EuroQol 5-dimensional 3-level version	**PFS**	Progression-Free Survival
FACT-Br	Functional Assessment of Cancer Therapy - Brain	**Preop**	Preoperative
F/U	Follow-up	**Postop**	Postoperative
GBM	Glioblastoma	**QoL**	Quality of Life
HGG	High-Grade Glioma	**rBM**	Recurrent Brain Metastases
HR	Hazard Ratio	**rGBM**	Recurrent Glioblastoma
ICU	Intensive Care Unit	**rHGG**	Recurrent High-Grade Gliomas
IDH	Isocitrate Dehydrogenase (enzyme)	**RN**	Radiation Necrosis
IFR	In-field Recurrence	**SAE**	Serious Adverse Event
IQR	Interquartile Range	**SD**	Standard Deviation
KPS	Karnofsky Performance Status	**SLA**	Stereotactic Laser Ablation
LAANTERN	Laser Ablation of Abnormal Neurological Tissue using Robotic NeuroBlate™*	**SRS**	Stereotactic Radiosurgery
LGG	Low-Grade Glioma	**SRT**	Stereotactic Radiotherapy
LITT	Laser Interstitial Thermal Therapy	**WBRT**	Whole-Brain Radiotherapy
LOS	Length of Stay	**WHO**	World Health Organization
mFI	Modified Frailty Index	**Wks**	Weeks
Min	Minute(s)	**w/o**	Without
mL	Milliliter(s)		

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Recurrent or Metastatic Brain Tumor: Pooled Analyses

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Survival outcomes in patients with recurrent glioblastoma treated with Laser Interstitial Thermal Therapy (LITT): A systematic review

Montemurro N, Anania Y, Cagnazzo F et al. *Clin Neurol Neurosurg*. 2020;195:105942[3]

Study design

Systematic review from 2000 to evaluate the role of LITT in patients with recurrent glioblastoma (rGBM). 17 articles were included in the analysis.

Patient population

- N = 219 procedures in 203 patients
- Men: 65.8%; Women: 34.2%
- Median age: 57.4 years

Outcomes

- Median length of stay (LOS): 3.5 days

Lesion details

- Main locations of ablation: frontal lobe (29%), temporal lobe (23.9%), parietal lobe (21.4%), occipital lobe (2.6%)
- rGBM located in thalamus, corpus callosum or cerebellum for 23.1% of patients
- rGBM's median volume before LITT: 8.9 cm^3

Procedural details

- LITT systems used: Signa SP/I™*, Visualase™, NeuroBlate™*
- 219 procedures in 203 patients
- Adjuvant chemotherapy received by all patients after LITT

Complications

- Most common complications: seizures (4 patients), motor deficits (3 cases), wound infection (3 cases), transient hemiparesis (2 patients) and hemorrhage (1 case)
- No deaths reported after LITT

Authors' conclusion

"Laser interstitial thermal therapy should be included in the armamentarium of neurosurgical oncologist for treatment of recurrent glioblastomas."

Laser ablation for cerebral metastases

Luther E, Mansour S, Echeverry N, et al. *Neurosurg Clin N Am*. 2020;31(4):537-547[4]

Study design

Systematic review from 2000 to evaluate the use of LITT in the management of metastatic brain tumors. 14 articles were included in this analysis.

Patient population

- N = 203 procedures in 156 patients (patient number not available in 1 article)
- Men: 31.08%; Women: 68.92% (data available in 11 articles)
- Weighted mean age: 58.86 years (data available in 10 articles)
- Median F/U: 12.12 months (data available in 9 articles)

Procedural details

- LITT systems not reported
- Primary indication for LITT: prior treatment failure as stereotactic radiosurgery or craniotomy (98.25%), patient preference (1.32%), LITT as initial treatment (0.44%)
- Extent of ablation: 97.04% (data available in 9 articles)

Lesion details
(data available in 11 articles)

- Primary cancer: mainly lung and breast cancer followed by melanoma
- Lesion locations: frontal lobe (65), posterior fossa (31), parietal lobe (20), temporal lobe (16), thalamus (7), parieto-occipital lobe (5), frontoparietal lobe (4), basal ganglia (3), insular (2), cingulate (1)
- Median preoperative lesion volume: 16.22 cm^3 (data available in 9 articles)

Complications

- Overall perioperative adverse event rate: 18.42% (data available in 14 articles)
- Overall adverse event rate at last follow-up: 5.26%
- Most frequent AEs: neurologic events (n = 28). The majority were resolved with medical management
- Less common AEs: symptomatic cerebral edema (3), postablation seizures (3), intracranial hemorrhage (2), infection (2), hydrocephalus (1), probe misplacement (1), hyponatremia (1), cerebrospinal fluid leak (1)

Authors' conclusion

"Although LITT carries slightly more upfront risk than SRS, it still can provide a minimally invasive option for various surgically inaccessible lesions. Further trials are needed to assess the relative efficacy of LITT in the management of cerebral lesions compared with standard therapies."

Stereotactic laser ablation as treatment of brain metastases recurring after stereotactic radiosurgery: a systematic literature review

Alattar AA, Bartek J, Chiang VL, et al. *World Neurosurg*. 2019;128:134-142.[5]

Study design

Systematic review from 1990 to summarize outcomes after LITT treatment in patients with glioblastoma recurring after stereotactic radiosurgery (rGBM). 13 articles were included in the analysis.

Patient population

- N = 142
- Further demographics not reported

Procedural details

- LITT systems not reported

Lesion details

- Not reported

Outcomes

Mean length of stay in ICU: 1.8 days (median: 1 day)

- Mean total hospital stay: 1 to 5 days (median: 1 to 2 days)

Complications

- Incidence of permanent neurologic events related to LITT treatment: <10%
- Reported complications:
  - Catheter misplacement (reported in early studies only; up to 14.2%)
  - Infection (1% to 2%)
  - Hydrocephalus (1%)
  - Hemorrhage (0.98% to 14.2%)
  - Transient neurologic deficits with subsequent recovery (8.82% to 35.3%),
  - Permanent neurologic deficits (2.17% to 7.14%)
  - Malignant edema requiring hemicraniectomy (4 cases identified in 3 articles)

Authors' conclusion

"A review of the SLA [LITT] literature provides sound rationale for continued development of SLA [LITT]as treatment of BMRS [brain metastases recurring after stereotactic radiosurgery]."

Recurrent or Metastatic Brain Tumor: Prospective and Retrospective Studies

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An analysis of functional outcomes following laser interstitial thermal therapy for recurrent high-grade glioma

Wilhelmy B, Serra R, Chen C, et al. *Neurosurg Focus*. 2024 ;57(5):E4.[6]

Study design

Retrospective single-center analysis of 47 consecutive patients with rHGG treated by LITT from 2019 to 2023 to evaluate the link between LITT treatment and functional outcomes, assessed by change in KPS score before and after LITT.

Patient population

- N = 47
- Mean age: 57 (14.2) years
- Men: 26, Women: n = 21
- KPS score ≥ 90 for 19 patients
- Patient's most significant comorbidities (mFI-5) from 0 to 5: 1 (1 – 2)

Lesion details

- Type of rHGG: glioblastoma (35), grade 3 astrocytoma (5), grade 4 IDH-mutant astrocytoma (3), grade 3 oligodendroglioma (3), or gliosarcoma (1)
- Main tumor locations: frontal, 47%; temporal, 30%; parietal, 23%
- Multilobar tumor 38%, multifocal tumor 23%
- Median tumor volume: 12.8 cm^3 (IQR: 5.5 – 21.5 cm^3)
- Median tumor depth: 8.7 mm
- Median midline shift: 2.2 mm (IQR: 1.4 – 3.1 mm)

Procedural details

- NeuroBlate™* system used
- Median treatment duration: 91.5 min (IQR: 60.0 – 130.5 min)
- Number of trajectories:
  - 1 trajectory, 51%
  - 2 trajectories, 34%
  - 3 trajectories, 15%
- Mean extent of ablation: 87.9% (12.0%)
- Previous treatment: surgery, 100%; chemotherapy, 77%; radiation therapy, 79%

Outcomes

- Change in KPS score after LITT (n): stable (19), improved (9), worse (17), unknown (2)
- Regression analysis showed that tumor volume was negatively correlated with change in KPS score ($p = 0.0387$; i.e. larger tumors were less likely to have stable or improved KPS scores after LITT)
- Logistic regression demonstrated 4.2 times greater odds of achieving a stable or improved KPS score for rHGG < 20 cm^3 ($p = 0.0497$)
- Complications were not discussed

Authors' conclusion

"The majority [of the patients] had a favorable functional outcome and tumor volume was inversely associated with post-LITT functional outcome. Those patients with a treated tumor volume < 20 cm^3 were significantly more likely to maintain or experience improvement in their neurological function after LITT."

Exploring the efficacy and safety of laser interstitial thermal therapy for recurrent high-grade glioma: the first prospective cohort in China

Wang Y, Chen S, Shi J, et al. *Clin Transl Oncol*. 2024.[7]

Study design

Prospective study of patients enrolled between March 2021 and December 2022 to evaluate outcomes of LITT for rHGG.

Patient population

- 32 patients
- 26 men, 6 women
- Age: 49.47 (13.49) years
- Mean F/U (range): 15.0 months (range, 1 - 33 months)

Lesion details

- 23 WHO grade IV lesions
- 9 WHO grade III lesions
- 20 patients had a single lesion; 12 patients had multiple lesions
- Single lesion location: Frontal (7), parietal (5), temporal (3), corpus callosum (2), occipital (1), cerebellum (1), thalamus (1)
- Multiple lesion location: Temporal (4), corpus callosum (1), frontal/corpus callosum (1), frontal/insular (1), frontal (1), frontal/temporal (1), perilateral ventricle (1), parietal (1), parietal/temporal (1)
- Mean pre-LITT tumor volume (SD): 5.767 (3.305) cm^3

Procedural details

- SinoVision™* LITT system
- Procedure time and extent of ablation

Patient group	Procedure time (SD), min	Extent of ablation (SD), %
All	147.00 (44.3)	90.42 (5.90)
WHO grade IV	147.70 (38.20)	89.83 (6.20)
WHO grade III	145.10 (61.10)	91.91 (5.07)

Outcomes

- Mean LOS (SD): 5.54 (2.16) days

Complications

- Complication rate: 9.38%
- Focal seizure attack (2)
- Fever (1)
- "No permanent complications related to the surgery or deaths within 30 days that were related to the LITT procedure were recorded."

Authors' conclusion

"As a minimally invasive treatment approach that can be tailored to an individual's anatomy and physiology, LITT offers an additional option for patients who are not suitable candidates for resection."

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Combination laser interstitial thermal therapy plus stereotactic radiotherapy increases time to progression for biopsy-proven recurrent brain metastases

Grabowski MM, Srinivasan ES, Vaios EJ et al. *Neurooncol Adv*. 2022;4(1):1-9[8]

Study design

Retrospective multicenter study to evaluate the efficacy of LITT performed after stereotactic radiotherapy (SRT) in rBMs. Data from patients who underwent LITT + SRT, LITT alone and repeat SRT alone between 2012 and 2019 for biopsy-proven brain metastasis recurrence after failure of prior SRT were analyzed. The LITT system used was not reported.

Outcomes

		LITT alone, n = 25	LITT + SRT, n = 21	Repeat SRT alone, n = 9	p-value
Patient population	Sex	18 women, 7 men	7 women, 14 men	7 women, 2 men	0.01
	Age, years (IQR)	56 (47.5 – 63.5)	60 (57.5 – 69)	60 (49.5 – 66)	NS
	F/U, mos (IQR)	5.9 (3.2 – 9.7)	12.7 (6.8 – 23.4)	6.2 (5.7 – 11.3)	0.01
Lesion details	Main primary pathologies	NSCLC: 60% Breast: 20%	NSCLC: 29% Breast: 19%	Breast: 56% NSCLC: 33%	N/A
	Target lesion locations	Frontal (15) Parietal (5) Deep (2) Cerebellar (2) Occipital (1)	Parietal (8) Frontal (5) Deep (4) Cerebellar (2) Occipital (1) Temporal (1)	Frontal (3) Cerebellar (3) Parietal (1) Occipital (1) Deep (1)	N/A
	Pre-LITT lesion size (range), cm^3	5.9 (2.5-8.1)	4.9 (3.3-19.4)	9.3 (3.4-11.5)	N/A
Procedural details	Previous whole brain radiotherapy	28%	0%	56%	0.01
	Number of trajectories (range)	1 (1 – 2)	1 (1 – 1)	N/A	NS
Outcomes	Hospital LOS days (IQR)	2 (1 – 3)	1 (1 – 3)	N/A	NS

Complications were not discussed.

Authors' conclusion

"Prospective trials are warranted to validate the efficacy of using combination LITT + SRT for treatment of recurrent brain metastases."

Magnetic resonance imaging-guided laser interstitial therapy for in-field recurrence after stereotactic radiosurgery: is complete ablation required for local control?

Dadario NB, Iqbal MO, Quinoa T, et al. *World Neurosurg*. 2022;168:e119-e131[9]

Study design

Retrospective single center study to report the site's experience with LITT for the treatment of in-field recurrence (IFR, i.e. reappearance of brain metastases within the area that was previously treated). Data from patients with IFR treated between 2010 and 2016 were analyzed.

Patient population

- N = 35, treating 47 different metastases
- Age: 64 (11) years
- Patients with evidence of radiologic progression of the BM but poor candidates for additional radiation therapy

Complications

- Complication rate: 25.5%
- Most common postoperative complication: new or increased motor weakness (n = 8)

Lesion details

- Pre-LITT tumor volume (n = 47): 3.80 (3.13) cm^3

Outcomes

- Median LOS: 1 day

Procedural details

- Visualase™ system used
- 23 lesions were sub-totally ablated and were pre-operatively bigger than lesions totally ablated (pre-operative tumor volume of 4.97 cm^3 vs. 2.36 cm3, p = 0.003, respectively)
- Volume ablation for sub-totally ablated lesions: 82 (12) %
- Residual tumor volume for subtotally ablated lesions: 0.93 (0.88) cm^3
- Total ablation time (n = 44): 288 (163) min

Authors' conclusion

"The benefits of more aggressive gross total ablations of deep targets near eloquent cortices are limited compared with effective subtotal ablation, but the amount of residual tumor volume left must be appropriately balanced."

Management of intracranial metastatic disease with laser interstitial thermal therapy

Salehi A, Kamath AA, Leuthardt EC, et al. *Front Oncol*. 2018 ;31:8:499[10]

Study design

Retrospective single center study to describe the ablation by LITT of metastatic lesions between 2010 and 2016.

Patient population

- N = 25 treated lesions in 24 patients
- Age: 59 years (range; 38 – 74)
- Mean F/U: 16.05 mos (range; 0.7 – 46.73)

Lesion details

- Main primary pathologies: lung 64%, melanoma 12%, breast 8%
- Lesion locations: frontal 44%, parietal 32%
- Mean pre-LITT lesion volume: 7.32 cm^3 (range; 1.00 – 24.59)
- Treatments before LITT: craniotomy and radiation therapy (6 patients), craniotomy and SRS/Gamma knife (4 patients), SRS and no craniotomy (6 patients)

Procedural details

- NeuroBlate™* system used
- Mean time of surgery: 219 min (range; 105 - 490)

Complications

- 1 perioperative complication: seizure
- 4 postoperative complications leading to readmissions within 3 days: seizure (1), edema (2) due to hyponatremia or transient hemiparesis, confusion (1)
- Cases with complications were associated with a larger volume of the lesion compared to those who had no complications (mean volume 12.32 (7.4) cm^3 vs. 5.93 (4.96) cm^3, respectively, p = 0.032)

Authors' conclusion

"LITT is an increasingly attractive treatment modality for various types of intracranial lesions including brain metastasis."

Newly Diagnosed Brain Tumor: Pooled Analysis

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Safety and efficacy of laser interstitial thermal therapy as upfront therapy in primary glioblastoma and IDH-mutant astrocytoma: a meta-analysis

Pandey A, Chandla A, Mekonnen M, et al. *Cancers*. 2024;16:2131.[11]

Study design

Systematic review and meta-analysis from 1983 to evaluate LITT in the upfront treatment of primary tumors (i.e. non-recurrent, non-metastatic tumors) in an adult population. A total of 22 studies were included in the analysis, including 16 studies with primary IDH-wild type glioblastoma (GBM) and 6 studies with IDH-mutant astrocytoma. Due to limited sample sizes, data with meningiomas and oligodendrogliomas were not analyzed. Tumor types were stratified according to the 2021 WHO Classification of Tumors of the CNS (WHO CNS5) when possible.

	Primary GBM	IDH-mutant astrocytoma
Patient population	• N = 185 patients • Mean age: 59.6 (5.6) years • Mean KPS score: 80.6 (3.5) • Mean F/U of 12.11 mos	• N = 21 patients • Mean age: 38.6 (6.3) years • Mean KPS score: 81.7 (7.6) • Mean F/U: 18.46 mos
Lesion details	• Main locations: thalamus 33.3%, frontoparietal region 19.3%, corpus callosum 14.9%, parietal and occipital, < 1% • Mean pre-LITT lesion volume: 18.1 (9.23) cm^3	• Main locations: frontoparietal region 44%, thalamus and temporal lobe 16%, insula 11%, corpus callosum or occipital lobe 5,6% • Mean pre-LITT lesion volume: 13.4 (13.4) cm^3
Procedural details	Not reported	• Not reported
Outcomes	• Mean extent of ablation (EOA): 94.8 (6.1) % • Mean postoperative KPS: 76.5 (14.2)	• Mean extent of ablation: 84.6 (4.1) %
Complications	• Pooled neurologic complication rate: 10.3% including transient aphasia 16.7%; non-specified neurologic deficits 4.5%; hemiparesis 1.3%; seizure 0.2% • Pooled non-neurologic complication rate: 4.8% including meningitis 16.7%; deep vein thrombosis 1.6%; pulmonary embolism 1.4%; cerebral edema 1.3%; hydrocephalus 0.4%	• Pooled neurologic complication rate: 33.0% including seizure 14.9%; motor deficit 12.8%; non-specified neurologic deficits 8.8%; hemiparesis 3.6% • Pooled non-neurologic complication rate: 8.3% including cerebral edema 12.4%; wound infections 6.9%

Authors' conclusion

"We found that LITT for IDH-wildtype GBM provides acceptable EOA with similar to reduced complication rates when compared to surgical resection. Our investigation into IDH-mutant astrocytoma demonstrated slightly lower EOA on average with higher complications, though it is difficult to draw any robust conclusions from this cohort given its extremely limited size of just 21 patients."

Newly Diagnosed Brain Tumor: Prospective and Retrospective Studies

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Evaluating laser interstitial thermal therapy for newly diagnosed, deep-seated, large-volume glioblastoma: survival and outcome analysis

Khalafallah AM, Shah KH, Knott MV et al. *Neurosurg Focus*. 2024 1;57(5):E3.[12]

Study design

Retrospective single center study to compare LITT outcomes in patients with large deep-seated newly diagnosed glioblastoma (ndGBM) versus small deep-seated ndGBM. Data of patients treated with LITT from 2013 to 2023 was analyzed. Patients with recurrent GBM were excluded from the analysis.

		Lesion volume ≥ 10 cm^3	Lesion volume < 10 cm^3	p-value
Patient population	N = 33	N = 23	N/A
	19 men, 14 women	14 men, 9 women	NS
	Mean age: 65.7 (10.2) years	Mean age: 67.0 (12.5) years	NS
	Preop KPS score: 80 (range, 70 – 80)	Preop KPS score: 80 (range, 80 – 80)	0.009
Lesion details	Mean pre-LITT lesion vol: 36.0 (21.6) cm^3	Mean pre-LITT lesion vol: 5.2 (2.7) cm^3	<0.001
	Main locations#: parietal 36.36%; temporal 33.33%; frontal 30.30%	Main locations#: temporal 31.13%; frontal 30.43%; parietal 26.09%	NS
	Main deep-seated structures: corpus callosum 11; hippocampus 6; basal ganglia 5; insula 4; thalamus 4; amygdala 3	Main deep-seated structures: corpus callosum 6; hippocampus 6; thalamus 4; basal ganglia 2; insula 2; amygdala 2; cerebellum 1	NS
Procedural details	LITT system used not reported		
	LOS: 3.9 (3.5) days	LOS: 3.3 (2.1) days	NS
	Surgery time: 256 (70.7) min	Surgery time: 212 (84) min	0.045
	Ablation time: 11.5 (4.6) min	Ablation time: 7.1 (3.1) min	<0.001
	1 trajectory for 82% of patients	1 trajectory for 96% of patients	NS
	Median no. of pullbacks: 4 (IQR, 3 - 4)	Median no. of pullbacks: 2 (IQR, 1 – 3.5)	<0.001
	EOA: 121.2% (47.9%)	EOA: 195.2% (127.1%)	0.013
Outcomes	30-day readmission: 15%	30-day readmission: 0%	NS
	Postop radiation therapy# (92%) or chemotherapy# (100%)	Postop radiation therapy# (100%) or chemotherapy# (93%)	
	Lesion volume did not significantly affect the hazard ratio for patients undergoing LITT (HR 1.16; 95% CI: 0.83 – 3.29; p = 0.150) Older age at surgery and 30- day readmission rate were factors predictive of reduced OS		
Complications	Complications < 30 days#: 21.21%	Complications < 30 days#: 32.58%	NS
	Postop edema < 30 days#: 4%	Postop edema < 30 days#: 0%	NS
	New motor deficit < 3 mos#: 8%	New motor deficit < 3 mos#: 38%	NS
	New speech deficit < 3 mos#:10%	New speech deficit < 3 mos#: 15%	NS
	Death: 76%	Death: 70%	NS

#: data was unavailable for all patients, N/A = not applicable, NS = not significant

Authors' conclusion

"Our study indicates that LITT is safe for large, deep-seated ndGBM. There was no increase in postoperative morbidity for patients with large ndGBM."

Laser interstitial thermal therapy for first-line treatment of insular glioma

Fadel HA, Pawloski JA, Anzalone AJ, et al. *J Neurosurg*. 2024;141(5):1292-1303.[13]

Study design

Retrospective single center study to describe site's experience using LITT to treat insular gliomas. Data of patients with treatment-naïve insular gliomas treated with LITT from 2015 and 2023 were analyzed. Gliomas could have a part outside of the insular structure which was resected with a standard open craniotomy.

	Insular- (glioma confined to the insula without extra-insular involvement)	Insular+ (glioma with extension into the frontal and temporal lobes)	p-value
Patient population	• N = 12 • Mean age: 47.9 (14.9) years • Preop KPS score: 80 for 1 patient, 90 for 5 patients and 100 for 6 patients, • F/U: 737 (IQR, 330 – 1101) days	• N = 10 • Mean age: 53.8 (13.1) years • Preop KPS score: 90 for 6 patients and 100 for 4 patients • F/U: 354 (IQR, 91 – 489) days	NS NS 0.0443
Lesion details	• Median pre-LITT lesion volume: 13.4 (IQR: 10.6 – 26.3) cm^3 • WHO grade 4: 25% of patients	• Median pre-LITT lesion volume: 81.2 (IQR: 51.9 - 97) cm^3 • WHO grade 4: 50% of patients	<0.001
Procedural details	OS and PFS not discussed		
	Median EOA: 100 (IQR, 92.1 - 100) LOS: 1 day for 100% of patients Single LITT ablation for 7 patients	Median EOA: 96.6 (IQR, 93.7 - 100) LOS: 1 day for 20% of patients, 2 days for 30% of patients, more than 3 days for 50% of patients Single LITT ablation for 7 patients	NS
Outcomes	OS and PFS not discussed		
	KPS score at 1st postop appointment: KPS score = 80: 1 patient KPS score = 90: 7 patients KPS score = 100: 4 patients	KPS score at 1st postop appointment: KPS score = 0: 1 patient KPS score = 60: 2 patients KPS score = 80: 1 patient KPS score = 90: 4 patients KPS score = 100: 2 patients	NS
Complications	• 2 patients had new postoperative neurological deficit • 1 patient with permanent neurological deficits at 6-8 weeks (aphasia)	• 5 patients had new postoperative neurological deficit • 3 patients with permanent neurological deficits at 6-8 weeks (aphasia) • 1 death due to postop hematoma after surgical resection	NS

Authors' conclusion

"We feel that the value of the current report is to describe a rationale and framework for treating insular gliomas with LITT alone or in conjunction with open surgery with relative safety, and our data can inform the growing discussion on the use of LITT to treat these challenging tumors."

Laser interstitial thermal therapy for newly diagnosed glioblastoma

Muir M, Patel R, Traylor JI, et al. *Lasers in Medical Science*. 2022;37:1811-1820.[14]

Study design

Retrospective single center study to describe site's experience using LITT to treat ndGBM.

Patient population

- N = 20 patients
- 12 men, 8 women
- Age: < 60 for 11 patients, > 60 for 9 patients
- Preop KPS score ≥ 70 for 19 patients

Lesion details

- Median pre-LITT lesion volume: 11.34 cm^3
- Main locations: thalamus (n = 8), corpus callosum (n = 6), insular (n = 3)
- Lesions in eloquent locations (n = 9) and lesions in near-eloquent locations (n = 11)
- IDH wild type for 14 patients, information unknown for 6 patients
- Treatments before LITT: none 80%, radiation 20%, chemotherapy 15%

Procedural details

- LITT systems used: NeuroBlate™* or Visualase™
- Complete ablation for 10 patients

Outcomes

- Postop KPS score ≥ 70 for 15 patients
- LOS < 5 days for 13 patients (65%)
- Adjuvant treatments for 15 patients
- Post-LITT treatment: radiotherapy 65% (13/20), chemotherapy 60% (12/20)

Complications

- New or worsened motor deficit for 60% (12/20) of patients with only 20% (4/20) of patients with symptoms lasting longer than 30 days (weakness for 3 patients and hemiparesis for 1 patient)
- Postop medical complications for 2 patients (seizure)

Authors' conclusion

"LITT is a safe… alternative to conventional resection in patients with inoperable, newly diagnosed GBM."

A cohort study on prognostic factors for laser interstitial thermal therapy success in newly diagnosed glioblastoma

Di L, Wang CP, Shah AH et al. *Neurosurg*. 2021;89:496-503.[15]

Study design

Retrospective single center study to identify prognostic factors for LITT treatment success in patients with ndGBM. Data of patients treated with upfront LITT between 2014 to 2020 was analyzed. Patients with recurrent GBM were excluded.

Patient population

- N = 20 patients
- 12 men, 8 women
- Mean age: 63.2 (9.1) years
- Median F/U: 10.3 (IQR, 4.0 – 14.4) mos

Lesion details

- Mean pre-LITT lesion volume: 41 (23.3) cm^3
- Main lesion locations: frontal (n = 6), temporal (n = 6), subcortical (n = 4), and parietal (n = 3)
- IDH wild type for 15 patients, IDH-mutated for 1 patient and unknown for 4 patients

Procedural details

- LITT system used: Visualase™
- Total laser power ranged from 5.1 to 14.4 Watts
- Time of ablation ranged from 54.7 to 1780 seconds
- Mean EOA: 87.7 (15.7) %
- Increased EOA was significantly associated with increased total laser power during ablation (p <0.001)

Outcomes

- All patients received adjuvant radiotherapy and chemotherapy (Temozolomide) after LITT according to Stupp protocol

Complications

- No major complications reported
- 11 minor complications reported in 8 patients: confusion (4; 1 unresolved), headache (2), memory issues (1), visual deficits (1; unresolved), fatigue (1; unresolved), nausea (1; unresolved), and insomnia (1; unresolved).

Authors' conclusion

"A strategy favoring higher laser power during tumor ablation may achieve optimal EOA."

Mixed Population: Pooled Analyses

Medtronic

Evaluating efficacy and safety of laser interstitial thermal therapy in patients with newly diagnosed and recurrent glioblastoma: a systematic review and meta-analysis

Rangwala HS, Shafique MA, Mustafa MS et al. *Neurosurgical Review*. 2024;47:846[16]

Study design

Systematic review and meta-analysis up to March 2024 to analyze the outcomes of LITT in patients with newly diagnosed and recurrent supratentorial glioblastoma in an adult population. A total of 15 studies were included in the analysis.

Patient population

- N = 239 patients
- 148 men, 45 women; sex not specified in 46 patients
- Age range: 34 to 78 years

Lesion details

- Main locations: thalamus, basal ganglia, corpus callosum, insula

Procedural details

- LITT systems used: NeuroBlate™* (11/15 studies) and Visualase™ (4/15 studies)
- Mean pre-LITT lesion volume: 18.23 cm^3 (95% CI:14.591 – 21.860 cm^3; data available in 12 studies)

Outcomes

- LOS: 13.07days (95% CI: 4.67 – 21.47 days; data available in 7 studies)

Complications

- Complication rate: 33.6% (data available in 11 studies, 43 events in 121 patients)
- Mortality rate: 3.3% (data available in 12 studies, 6 events in 190 patients)

Authors' conclusion

"LITT shows promise for treating both newly diagnosed and recurrent glioblastoma cases in non-surgical candidates…. However, higher complication and mortality rates were noted, emphasizing the need for additional well-designed prospective multicenter trials."

LITTing up gliomas – Is the future bright?

O'Halloran PJ, Henry J, Amoo M, et al. *World Neurosurg*. 2023;17:100136.[17]

Study design

Systematic review and meta-analysis until 2021 to assess LITT for ablation of primary and recurrent glioma. 16 studies were included in the meta-analysis.

Patient population

- N = 401 patients with 408 treated gliomas
- Further demographics not reported

Lesion details

- Weighted median lesion volume: 13.95 cm^3
- 62.8% of primary glioma and 37.2% of recurrent glioma – data available for all tumors
- 28.8% of grade 1 or 2 and 71.2% of grade 3 or 4 - tumor grade available for 306 gliomas
- Lesion location: frontal (n = 80), temporal (n = 39), thalamic (n = 37), parietal (n = 36), corpus callosum (n = 31), parieto-occipital (n = 16), and insular (n = 9); data available for 248 gliomas

Procedural details

- LITT systems used: NeuroBlate™* and Visualase™

Outcomes

- Weighted median LOS: 3.7 days – data available in 10 studies

Complications

- Complication rate: 114 complications with a pooled estimated complication rate of 24% (95% CI: 14 – 35%)
- Main events reported: 44 transient deficits, 17 permanent deficits, 14 worsening deficits, 14 hydrocephalus/edema, 11 seizures, 7 infections, 6 intracranial hemorrhage, 1 cerebrospinal fluid leak

Authors' conclusion

"Maximal resection with adjuvant chemoradiation remains the gold standard for treatment of high-grade glioma where feasible. However, LITT offers a minimally invasive therapeutic strategy that may potentially be efficacious in the treatment of deep-seated or recurrent gliomas and should be further investigated in randomized controlled trials."

Laser interstitial thermal therapy for posterior fossa lesions: a systematic review and analysis of multi-institutional outcomes

Sabahi M, Bordes SJ, Najera E, et al. *Cancers* 2022, 14, 456.[18]

Study design

Systematic review to assess LITT for the ablation of tumors in the posterior fossa. Literature search was performed in September 2021. 16 studies were included in the analysis.

Patient population

- N = 150 patients underwent LITT procedure between 2014 and 2021
- 76.1% women, 23.9% men
- Mean age: 56.47 years
- Pre-KPS score: 90 (data available for 38 patients)
- F/U range: 2 to 24 mos

Complications

- Procedure-related complication rate, including new neurologic deficits: 14.5% (19/131)
- No complication for 78.6% of the pooled sample (103/131)
- Posterior fossa syndrome identified for 6/131 patients, including slurred speech (n = 2), scanning speech (n = 1), speech impairment (n = 1), dysarthria (n = 1), and dysarthria due to a new lesion (n = 1)

Lesion details

- Lesion type (data available for 111 lesions):
  - Primary pathology (n = 104): breast cancer, brain lesions (tumor/vascular abnormalities/ epileptic focus), lung cancer, renal and gastrointestinal cancer, and other metastases
  - RN (n = 7)
- Lesion location (data available for 128 lesions): cerebellum (n = 110), brain stem (n = 13), cerebellar peduncle (n = 3), vermis (n = 1), and pineal region (n = 1)
- Mean pre-LITT lesion volume: 3.93 cm^3 (data available for 104 patients)
- Mean post-LITT cavity volume: 6.16 cm^3 (data available for 79 patients)
- Treatment regimens before LITT (data available for 134 patients): SRS (n = 82), combination therapy (n = 25), resection (n = 10), radiotherapy (n = 2), and no prior treatment (n = 15)

Outcomes

- Post-KPS score: 80 (data available for 38 patients)
- Mortality outcomes (data available for 131 patients): No death due to LITT procedure

Authors' conclusion

"The use of LITT for the treatment of posterior fossa lesions continues to show promise."

Mixed Population: Prospective and Retrospective Studies

Medtronic

Laser interstitial thermal therapy in neurosurgery: a single-surgeon experience of 313 patients

Gurses ME, Lu VM, Gecici NN, et al. *J Neurosurg*. 2024 ;141(5) :1281-1291.[19]

Study design

Retrospective single-center study to evaluate the outcomes after LITT to ablate various brain tumors. 313 consecutive LITT procedures performed by one surgeon between 2013 and 2023 were analyzed.

Patient population

- N = 313 patients with 317 treated lesions (63.4% recurrent)
- 183 women, 130 men
- Mean age: 60.4 (13.3) years
- Mean preop KPS: 80 (range, 50 – 100)
- Patients with preop neurological deficits: 70.9%
- Patients with preop seizures: 24%
- Mean F/U: 10.4 (18.03) mos

Outcomes

- Mean LOS: 6.7 (14.9) days and median LOS: 2 (IQR, 2 – 3) days
- Median postoperative KPS: 90 (range, 80 – 90)
- Repeat intervention for recurrence: LITT 71.1% and surgery 28.9%
- Readmission within 30 days: 10.9%
- Mean postop volume 24h after LITT: 15.8 (45.6) cm^3

Lesion details

- Lesion subtypes: GBM 41.6% (including ndGBM 22.7% and rGBM 18.9%), metastases 30%, RN 11.4%, LGG 9.1%, meningioma 2.2%, other 5.7%
- Main lesion location: supratentorial region 90.9% of patients
- Mean pre-LITT lesion volume: 11.32 (19.9) cm^3. Mean preop volume of GBM significantly higher compared with that of metastatic lesions ($p < 0.001$), LGG ($p = 0.005$), and RN ($p = 0.003$)

Procedural details

- LITT system used: Visualase™
- Mean operative time: 227.5 (71.6) min with a mean ablation time: 7.31 (3.93) min
- Single trajectory: 93.9% of patients
- Mean EOA: 190.6 (198.2%). EOA was > 100% for 75.7% of treated lesions

Complications

- Postoperative complication rate: 4.5% (14/313; 5 hemorrhage)
- Main events after postoperative period: temporary deficits 16.3% (n = 51); Permanent deficits 14.1% (n = 44): preoperative deficits that persisted after surgery 6.1%, motor weakness 1.6%; visual deficits 1.3%; new-onset seizures 1%; hydrocephalus requiring shunt 1%; gait disturbance 1%; aphasia 1%; cognitive deficits 0.6%; hypoglossal palsy 0.3%; and hemispatial neglect 0.3%

Authors' conclusion

"LITT remains a versatile adjunctive treatment option for patients encountering treatment failure or facing tumors inaccessible through conventional open surgery. However, patient selection for LITT warrants careful consideration by neurosurgeons."

Laser interstitial thermal therapy for glioblastoma: a single-center experience

Traylor JI, Patel R, Muir M, et al. World Neurosurg. 2021;149:e244-e252.[20]

Study design

Retrospective single-center study to examine outcomes from a consecutive series of patients who underwent LITT, between 2013 and 2017, to treat ndGBM and rGBM.

Patient population

- N = 69 patients
- 43 men, 26 women
- Median age: 56 years (range, 15 – 77 years)

Lesion details

- Lesion types: rGBM 71.0%, ndGBM 29.0%
- IDH status: wild-type 87.3% and mutant 12.7% (data available for 55 patients)
- Lesion location: deep-seated lesions 39.1% and non- deep-seated lesions 60.8%
- Median pre-LITT lesion volume: 10.4 cm^3 (range, 1.0 – 64.0 cm^3) with volume < 10 cm^3 for 59.3% of the patients

Procedural details

- LITT systems used: Visualase™ and NeuroBlate™*
- Gross total ablation for 40.6% of the patients

Outcomes

- Median LOS: 2 days (range, 0 – 47 days)

Complications

- Permanent neurological complication rate: 24.6% (17/69) including 13 patients who had a persistent worsened motor deficit. Consequently, 4 patients had a new persistent motor deficit related to LITT. Note, a preexisting motor deficit was improved after LITT for 3 patients.
- Medical complication rate: 14.4% (10/69) including new-onset seizures (4 patients), impaired cognition in the follow-up period (3 patients), hyponatremia (2 patients), urinary tract infection (1 patient), pneumonia (1 patient), pulmonary embolism (1 patient), and acute kidney injury (1 patient).
- Serious complications leading to death occurred in 2 patients. One had decreasing consciousness and worsening oxygen saturation and died 20 days after LITT. The other was noted to have hyponatremia that was indicative of "inappropriate antidiuretic hormone secretion" that progressively worsened. The patient died 3 months after LITT due to disease progression.

Authors' conclusion

"LITT can safely reduce intracranial tumor burden in patients with GBM who have exhausted other adjuvant therapies or are poor candidates for conventional resection techniques."

Laser ablation of abnormal neurological tissue using robotic NeuroBlate system (LAANTERN): 12-month outcomes and quality of life after brain tumor ablation

Kim AH, Tatter S, Rao G, et al. *Neurosurgery*. 2020;87(3):E338-346.[21]

Study design

Prospective, multicenter, real-world evidence registry for patients who underwent LITT to ablate brain tumors. Across 20 centers, up to 1000 patients will be enrolled in this registry promoted by Monteris Medical Inc. This publication presents the 12-month QoL outcome in 223 patients enrolled in 14 US centers. QoL was assessed by FACT-Br and EQ-5D-3L questionnaires.

Patient population

- N = 223 pts with 231 lesions treated by LITT
- 119 women, 104 men
- Mean age: 54.3 (16.5) years
- Median Preop KPS score = 90 (range 50 – 100)
- Median F/U: 223 days (range not reported)

Lesion details

- Lesion type:
  - Primary brain tumor 58.7% including LGG 15.1% and HGG 84.9%
  - Metastatic brain tumor 41.3% including recurrent tumor (50.6%) and RN (40%)
- Main lesion location: frontal 41.6%, parietal 19% temporal 15.2%, occipital 8.2%, corpus callosum 2.6%, thalamus 8.7%, and deep nuclei 0.4%
- Mean pre-LITT lesion volume: 7.1 (14.7) cm^3
- 24,9% of lesions treated by LITT were considered difficult to access through open surgery; 58.6% of physicians said LITT was chosen for treatment because patients preferred a minimally invasive procedure.

Procedural details

- LITT system used: NeuroBlate™
- Single trajectory for 93.9% of patients
- Total procedure time: 193.1 (80.9) min
- Mean blood loss: 12.3 (36.9) mL
- > 90% ablation in 77% of procedures

Outcomes

- LOS: 33.4 (range 13 – 733) hrs
- FACT-Br total scores: mean decline of 4.5 and 4.3 points (of 200) at 1 and 3 mos ($p<0.05$ vs. baseline). No change at 6 and 12 mos.
- FACT-BR emotional well-being scores: mean improvement of 1 point at 1, 3, 6 and 12 mos ($p<0.05$ vs. baseline)
- EQ-5D-3L: improvement of sub scores for mobility, self-care, and usual activities from 1 to 12 mos vs. baseline
- EQ-5D-3L: stability of sub scores for pain/discomfort, anxiety/depression, and VAS from 1 to 12 mos vs. baseline
- No differences in FACT-Br and EQ-5D-3L scores between the primary and the metastatic patient populations

Complications

- LITT/surgery SAE rate: 1.8%; overall complication rate, 10.7%
- 30-day readmissions: 4

Authors' conclusion

"Results from the ongoing LAANTERN registry demonstrate that LITT stabilizes and improves QoL from baseline levels in a malignant brain tumor patient population with high rates of comorbidities."

Lessons learned in using laser interstitial thermal therapy for treatment of brain tumors: a case series of 238 patients from a single institution (1/2)

Shao J, Radakovich Nr, Grabowski M, et al. *World Neurosurg*. 2020;139:e345-e354.[22]

Study design

Retrospective single-center study to report on the site's experience with LITT procedures to ablate brain tumors. Data of consecutive patients who underwent LITT from 2011 to mid-2018 were analyzed. Evolution of practices and complications over time have been described.

Patient population

- N = 238 patients but LITT procedure was aborted in 6 patients due to equipment malfunction (3 patients) and absence of neoplasm (3 patients)
- 121 women, 117 men
- Age ≥ 65 years: 44.5%
- Preop median KPS: 90 (range, 50 – 100) – data available for 221 patients
- Median F/U: 8.4 mos

Lesion details

- Lesion types: HGG 59.3%, LGG 10.9%, metastases 8.8%, RN 21.0%
- 47.1% of patients were diagnosed upfront with biopsy at the time of LITT
- Lesion location: lobar 79.4%, deep-seated 16.8%, posterior fossa 3.8%

Procedural details

- LITT system used: NeuroBlate™*
- Mean surgery time: 4.7 (2.6) hrs (range, 1.0 – 13.9 hrs)
- 1 trajectory for 67.7% (157/232) of patients

Complications

- Permanent deficit rate: 10.8%
- Temporary deficit rate: 30.2%
- Patients with preoperative KPS ≤ 70 had an increased number of permanent motor deficits (17.6%) vs. patients with KPS > 80 (2.3%; $p<0.001$)

Lessons learned in using laser interstitial thermal therapy for treatment of brain tumors: a case series of 238 patients from a single institution (2/2)

Shao J, Radakovich Nr, Grabowski M, et al. *World Neurosurg*. 2020;139:e345-e354.[22]

Study design

Retrospective single-center study to report on the site's experience with LITT procedures to treat brain tumors. Data of consecutive patients who underwent LITT from 2011 to mid-2018 were analyzed. Evolution of practices and complications over time have been described.

Comparative analysis between the early and recent cohorts

	Early cohort: LITT performed between 2011 and 2014 N = 100 patients	Recent cohort: LITT performed between 2015 and mid-2018 N = 138 patients	P value
Patient population	• Mean age: 54.3 (15) years • Preop KPS: 85 (9.7)	• Mean age: 58.4 (15) years • Preop KPS: 83.2 (11)	**0.040** 0.213
Lesion details	• Lesion types: HGG 60.0%, LGG 14.0%, metastases 10.0%, RN 16.0% • Lesion location: lobar 80.0%, deep-seated 19%, posterior fossa 1% • Pre-LITT lesion volume ≥ 4 : 70.5% of patients (67/96)	• Lesion types: HGG 58.7%, LGG 8.7%, metastases 8.0%, RN 24.6% • Lesion location: lobar 79.0%, deep-seated 15.2%, posterior fossa 5.8% • Pre-LITT lesion volume ≥ 4 cm^3: 62.5% of patients (85/136)	0.280 0.133 0.261
Procedural details	• Mean surgery time: 6.67 (2.66) hrs • 1 trajectory for 53.1% of patients (51/96) • Mean LOS: 2.3 (2.2) days	• Mean surgery time: 3.57 (1.75) hrs • 1 trajectory for 77.9% of patients (106/136) • Mean LOS: 2.5 (3.7) days	**<0.001** **<0.001** 0.801
	• Authors stated, "A new generation of LITT system was released in 2013, leading to reduced ablative times and fewer trajectories."		
Complications	• Permanent motor deficit rate: 15.5% (15/96) • Permanent sensory deficit rate: 2.1% (2/96) • Temporary motor deficit rate: 23.9% (23/96) • Temporary sensory deficit rate: 3.1% (3/96) • Temporary seizure rate: 0% (0/96) • Hemorrhage rate: 19.6% (19) • Infection rate: 3.1% (3/96)	• Permanent motor deficit rate: 4.4% (6/136) • Permanent sensory deficit rate: 1.5% (2/136) • Temporary motor deficit rate: 19.1% (26/136) • Temporary sensory deficit rate: 0% (0/136) • Temporary seizure rate: 1.5 (2/136) • Hemorrhage rate: 21.3% (29/136) • Infection rate: 0% (0/136)	**0.005** 1.000 0.493 0.071 0.512 0.103 0.071
	• Significant decrease in permanent motor deficit between the 2 cohorts can be explained by "an important change in preoperative surgical planning" at the site (relevant motor fibers were visualized by MRI in order to prevent off-target thermal damage).		

Authors' conclusion

"LITT provides a minimally invasive method of photocoagulating defined targets via thermal energy with minimal compromise of adjacent structures. Recent developments in technology and experience have allowed us to improve both the efficiency and the safety of this surgery, as shown by the reduction in permanent motor deficits."

Magnetic resonance–guided laser interstitial thermal therapy for brain tumors in geriatric patients

Ginalis EE, Danish SF. Neurosurg Focus. 2020;49(4):E12.[23]

Study design

Retrospective single-center study to evaluate the safety outcomes from a geriatric cohort who underwent LITT from 2011 to 2019 to treat brain tumors. Short-term outcomes and mortality rates were analyzed. This geriatric cohort included 55 patients (age ≥ 65 years old), and it was split into 2 cohorts based on age. Percentages are calculated based on the number of cases (i.e. lesions).

	Patient cohort 1 (65 – 74 years), 47 lesions	Patient cohort 2 (≥ 75 years), 17 lesions	p-value
Patient population	• Median age: 69 (range, 65 – 74 years) • Median mFI: 0.1 (IQR, 0.1 – 0.2) – low frailty • Median CCI: 8 (IQR, 4 – 9) corresponding to a 0% 10-year survival rate	• Median age: 80 (range, 75 – 90 years) • Median mFI: 0.2 (IQR, 0.075 – 0.205) – intermediate frailty • Median CCI: 9 (IQR, 6 – 10) corresponding to a 0% 10-year survival rate	NS P<0.05
Lesion details	• Lesion types: primary tumor 40.4%, metastasis or RN 59.6%	• Lesion types: primary tumor 29.4%, metastasis or RN 70.6%	
	• Lesion location: frontal lobe 34.4%, parietal lobe 25%, temporal lobe 17.2%, cerebellum 15.6%, occipital lobe 3.1%, corpus callosum 1.6%		
Procedural details	• Median LOS: 1 (IQR 1 – 2)	• Median LOS: 1 (IQR 1 – 1)	NS
	• LITT system used: Visualase™ • Mean ablation time: 8.6 min (range, 0.87 – 30.9) • Mean ablation power: 11.4 W (range, 6-20 W) • Estimated blood loss was < 50 mL in all cases • The presence of a neurological symptom at baseline and the presence of a postoperative complication were • each associated with significantly longer hospital LOS (p < 0.05)		
Outcomes	• 30-day mortality: 2.1% (1/47) – not related to • LITT • Overall mortality: 8.5% • Discharge at home: 68.1%	• 30-day mortality: 0% • • Overall mortality: 5.9% • Discharge at home: 68.8%	NS
	• Patients with metastatic tumors were significantly more likely to be discharged home (79.5% of • cases) than those with primary tumors (54.2% of cases)		
Complications	• Acute neurological complication rate: 14.1% (9 patients for 64 cases), including weakness (n = 7), aphasia (n = 2), confusion due to symptomatic cerebral edema (n = 1), and cognitive deficits (n = 1). These events were resolved and partially resolved for 3 and 5 patients, respectively. This rate was not statistically significant between the two age groups. • Note, 1 perioperative complication (inaccurate laser placement) had led to a reoperation (suboccipital craniotomy) within 48 hrs after LITT.		

Authors' conclusion

"LITT can be considered a minimally invasive and safe neurosurgical procedure for the treatment of intracranial tumors, even for geriatric patients. Careful preoperative preparation and postoperative care is essential as LITT is not without risk. Appropriate patient selection for cranial surgery is essential, because neurosurgeons are treating an increasing number of elderly patients, but advanced age alone should not exclude patients from LITT without considering frailty and comorbidities."

Magnetic resonance guided laser interstitial thermal therapy for posterior fossa neoplasms

Ashraf O, Arzumanov G, Luther E et al. Journal of Neuro-Oncology. 2020;149:533-542.[24]

Study design

Retrospective single-center study to report patient outcomes after LITT to ablate tumors in the posterior fossa. Data from 2010 to 2020 were analyzed.

Patient population

- N = 58 patients with 60 lesions
- 40 women, 18 men
- Mean age: 56.4 years (range, 4 – 90 years)
- Median F/U: 9.5 mos (range, 0.6 – 81.5 mos) for 48 patients (50 lesions)

Outcomes

- Mean hospital LOS: 2.50 (0.42) days (range, 1 – 22 days). Mean hospital LOS for patients with brainstem and with cerebellar locations were 5.5 (2.52) days vs. 2.0 (0.24) days, respectively (p = 0.0416)
- 46 patients (79.3%) discharged home
- Additional treatment for 5 patients with recurrence: craniotomy (n = 2), radiosurgery (n = 1), chemotherapy regimen change (n = 2)

Complications

- Complication rate: 24.1% (14/58): new neurological deficits in 12 patients (persistent deficit at last F/U for 5 patients) and 2 procedural complications due to laser insertion (hemorrhage and catheter misplacement)
- 1 procedure-related mortality: one patient treated for a 6.2 cm^3 midbrain GBM died 8 weeks after LITT due to a refractory edema
- No 30-day readmissions

Lesion details

- Lesion location: cerebellum (n = 52), brainstem (n = 7) and pineal region (n = 1)
- 15 primary tumors: mainly GBM (n = 4), pilocytic astrocytoma (n = 3) and LGG (n = 2)
- 45 secondary tumors; 44 cases of infield recurrence and one untreated metastatic tumor. Primary tumor pathology mainly included breast cancer (n = 18), non-small-cell lung cancer (n = 16) and melanoma (n = 4).
- Pre-LITT mean lesion volume: 2.24 (0.21) cm^3
- 24 hr-postablation volume: 3.92 (0.28) cm^3
- Prior intervention for 53 patients: craniotomy (n = 6), radiotherapy (n = 1), or both craniotomy and radiotherapy (n = 3) for patients with primary tumors. Stereotactic radiosurgery (n = 34) or both craniotomy and stereotactic radiosurgery (n = 9) for patients with secondary tumors

Procedural details

- LITT system used: Visualase™
- Mean ablation time: 404.3 (44.6) seconds
- Mean number of ablations: 2.94 (0.27)
- Mean laser power: 9.3 (0.26) W

Authors' conclusion

"The average target size is smaller than what has been reported in the supratentorial space. Care must be taken to prevent injury to surrounding structures given the close proximity of critical structures in this region."

Predictors of local control of brain metastasis treated with laser interstitial thermal therapy

De Almeida Bastos DC, Rao G, Glitza Oliva IC, et al. *Neurosurgery*. 2020;87:112–122.[25]

Study design

Retrospective single-center study evaluating outcomes after LITT for a variety of tumor types. Data for consecutive patients with BM ablated with LITT between 2012 and 2017 were analyzed.

Patient population

- N = 61 patients with 82 lesions; final analysis included 59 patients and 80 lesions
- Median age: 58 years (IQR 49 – 67 years)
- Median pre-LITT KPS: 80 (IQR 80 -90)
- Median F/U: 7 mos (IQR 4 – 21.5 mos)

Lesion details

- Lesion type: 5 newly diagnosed, 46 recurrent, and 31 RN
- Median pre-LITT lesion volume: 4.02 cm^3 (range, 0.2 – 26.3 cm3)
- Treatment regimens before LITT: SRS alone (n = 38), SRS combined with WBRT (n = 15)
- No systemic treatment in the 3 mos prior to LITT for 36 patients
- No systemic treatment within the first 3 mos after LITT for 31 patients

Procedural details

- LITT systems used: Visualase™ from 2012 to 2015 (38 lesions treated) and NeuroBlate™* from 2015 to 2017 (44 lesions treated)
- Median ablation volume: 7.72 cm^3 (range, 1.52 – 26.72 cm^3)
- Median depth: 40 mm (range, 16 – 79 mm)

Complications

- Complication rate: 26.2% (16/61) including one death (intractable brain edema leading to uncal herniation and death 48 hrs after LITT), medical complications (4 patients) and surgical complications with neurological decline (11 patients; 8 were persistent)

Authors' conclusion

"The complication rate of this series is 26.2%, below what is usually reported. As with any surgical procedure, risk and benefits ought to be weighed against each other. However, considering that most patients were receiving salvage therapy after SRS and most lesions were deemed unresectable, our complication rates of LITT are in concordance with the literature when reporting similar cases."

Laser ablation after stereotactic radiosurgery: a multicenter prospective study in patients with metastatic brain tumors and radiation necrosis

Ahluwalia M, Barnett GH, Deng D, et al. *J Neurosurg*. 2019;130:804-811.[26]

Study design

Prospective multicenter study to determine functional outcomes of LITT in patients with recurrent brain metastases (rBM) and radiation necrosis (RN).

Patient population

- N = 42
- Age: 58.5 years (range, 32 – 74 years)
- Median KPS score: 85 (range, 60 – 100)
- Last F/U: 26 weeks

Lesion details

- Main primary tumor pathologies: non-small cell lung cancer, 43%; breast cancer, 17%; melanoma, 10%
- Mean lesion volume: 6.4 cm^3 (range, 0.4 – 38.6 cm^3)
- Main locations: frontal lobe, 41%; parietal lobe, 29%; cerebellum, 14%; other, 16%
- Pathology analysis of tumor: rBM, 48%; RN w/o evidence of tumor, 45%; tumor w/o diagnosis, 7%

Procedural details

- NeuroBlate™* system used
- Median procedure time: 3 hrs (range, 1.4 – 9.7 hrs)

Outcomes

- Median LOS: 2 days (range, 0.4 – 12.0)
- Median change in KPS: 0 (range, -40 to 20); 25/42 patients (60%) had stable or improved KPS at their last F/U
- Neurological improvement was seen in 3/11 patients (27%) at last F/U
- No significant change was seen in QoL measures

Complications

- Neurological complications related to LITT seen in 12% of patients

Authors' conclusion

"In this study, in which enrolled patients had few alternative options for salvage treatment, LITT ablation stabilized the KPS score, preserved quality of life and cognition, had a steroid-sparing effect, and was performed safely in the majority of cases."

Glioblastoma treated with magnetic resonance imaging-guided laser interstitial thermal therapy: safety, efficacy, and outcomes

Kamath AA, Friedman DD, Akbari SHA et al. *Neurosurgery*. 2019;84:836-843.[27]

Study design

Retrospective single-center study to LITT for ablation of brain tumor in patients with GBM. Patients underwent LITT between 2010 and 2016 performed by 1 of 2 surgeons.

Patient population

- N = 54 patients with 58 treated GBM (histological diagnosis)
- 37 men, 17 women
- Mean age: 58.8 (10.8) years
- Mean F/U: 11.5 (7) mos

Lesion details

- Lesion type: primary lesions 29.3% and recurrent lesions 70.7% (including 14.6% second recurrences)
- Main lesion location: frontal 24.1%, parietal 15.5%, temporal 13.8%, corpus callosum 13.8%, and thalamic 13.8%
- Mean pre-LITT lesion volume: 12.5 (13.4) cm^3 (data available for 50 lesions)
- Main pre-LITT treatment regimen: resection + chemoradiation 56.9%, none/biopsy only 29.3%, chemotherapy and radiation only 6.9%

Procedural details

- LITT system used: NeuroBlate™*
- Primary reason for LITT: lesion location (32.8%) or advanced age, recurrence and/or poor functional status (67.2%)
- 1 trajectory for 84.5% of lesions
- Surgery time: 240 (125) min

Outcomes

- Mean ICU LOS: 1.7 (2.8) days
- Mean hospital LOS: 3.2 (4.6) days
- Post-LITT treatment regimen: chemotherapy 91.4%, radiotherapy 25.9%, surgery 5.2%, other 17.2%

Complications

- Complication rate within 30 days of procedure: 15.5% (9/58)
- Complications reported: cerebral edema (n = 3), seizures (n = 3), hydrocephalus (n = 1), hyponatremia (n = 1), and infection (n = 1)
- 2 deaths: 1 patient died due to a hemorrhage of his large parieto-occipital GBM that occurred after LITT, and 1 patient developed fulminant Enterobacter meningitis due to a sterilization issue.

Authors' conclusion

"Our experience suggests that LITT is a safe, well-tolerated and efficacious cytoreductive treatment for GBM in properly selected patients."

Intracranial MR-guided laser-induced thermal therapy: single-center experience with the Visualase thermal therapy system

Patel P, Patel NV, Danish SF. *J Neurosurg*. 2016;125:853-860.[28]

Study design

Retrospective single-center study to describe safety outcomes after LITT to treat different intracranial indications. LITT was performed between 2010 and 2014 in 102 patients. This summary covers outcomes related to brain tumors and RN only.

Patient population

- N = 87 patients with brain tumors treated 51 men, 51 women (all indications)
- Mean age: 53 (20.3) years (all indications)

Lesion details

- Lesion type:
  - Primary lesions for 50 patients, including GBM for 24 patients
  - Metastasis and RN for 37 patients

Outcomes

- Safety outcomes reported below

Procedural details

- LITT system used: Visualase™
- Surgery time:
  - Primary lesions: 2.9 (0.6) hrs (data available for 44 patients); laser time was 9.3 (6.5) min (data available for 50 pts)
  - Metastasis and RN: 2.8 (0.6) hrs (data available for 28 patients); laser time was 8.7 (8,1) min (data available for 36 patients)
  - Prep time, OR time, transfer time and MRI time were also reported in the publication for each diagnosis
- Mean ICU LOS: 1.8 (3.4) days (all indications)
- Mean hospital LOS: 3.6 (5.4) days (all indications)

Complications

- The numbers below represent patient numbers; all complications occurred in brain tumor and RN groups.

	New neurological deficits	Edema	Hemorrhage with craniotomy and evacuation	Inaccurate laser placement	Thermal injury	Infection at incisional site	Perioperative death
Primary lesions	7	4	2 (1 procedure aborted)	2 (1 procedure aborted)	0	1	2
Metastasis and RN	7	1	1	0	1	1	0

- New neurological deficits included motor deficits (n = 12), cognitive decline (n = 1), and vision & eye problems (n = 1)
- Complete resolution of new neurological deficits within 1 month for 9 patients and partial resolution in 1 patient; no resolution in 2 patients at last follow-up
- Hemorrhage included insertional hemorrhage (n = 2), and ablation-induced hemorrhage (n = 1)
- The 2 perioperative deaths were due to refractory edema after LITT procedure

Authors' conclusion

"LITT is promising as an efficient and effective treatment option for a wide range of neurological pathologies. In our study, this technique resulted in relatively few complications, many of which were temporary neurological deficits that were significantly improved with therapy."

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