

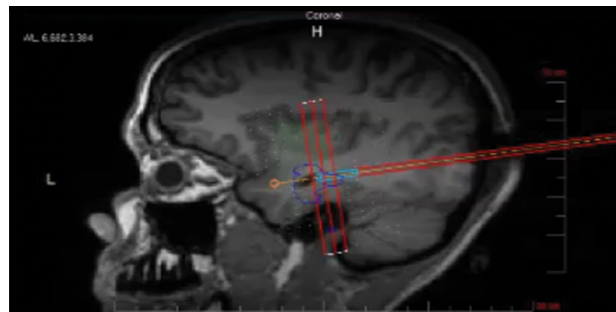
**Precision Without the Scalpel: Evaluating the Promise of Laser Interstitial Thermal
Therapy in Advancing Modern Neurosurgery Over Traditional Open Procedures**

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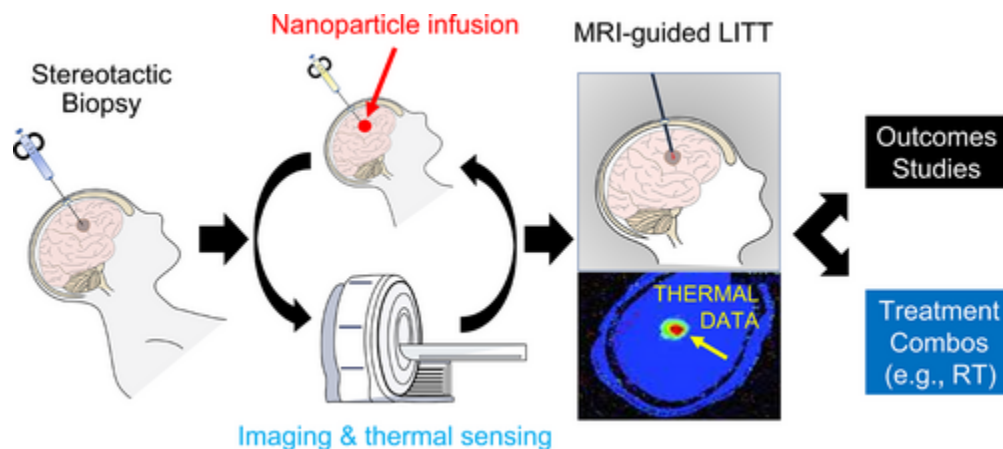
30 April 2025

"LITT surgery offers an innovative solution for treating brain conditions with fewer risks and a quicker recovery than traditional brain surgery. Unlike conventional methods, which often require the removal of part of the skull, LITT achieves its therapeutic effects with minimal disruption to the brain, reducing complications and enhancing the recovery process" (Duke 23).

Abstract for The Fundamentals of Laser Interstitial Thermal Therapy in Neurosurgery



(see appendix 8 for further analysis)



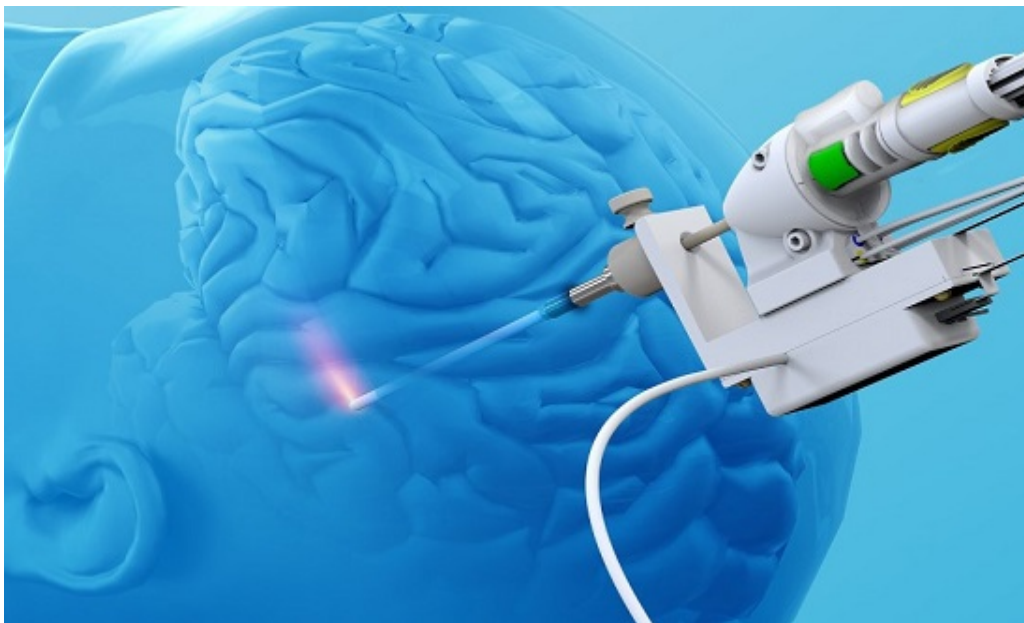
(see appendix 9 for further analysis)

Imagine treating complex brain conditions without the need for a major incision. Laser Interstitial Thermal Therapy (LITT) offers just that – an innovative, minimally invasive

neurosurgical technique that uses laser energy delivered through a precise, stereotactically guided fiber optic probe to target and destroy pathological brain tissue. Developed as a less invasive alternative to traditional craniotomy, LITT is rapidly gaining recognition for its ability to provide pinpoint accuracy, faster recovery, and fewer complications. It has shown particular promise in treating challenging conditions like medically intractable mesial temporal lobe epilepsy (MTLE) and recurrent glioblastoma multiforme (GBM). The procedure is performed under real-time magnetic resonance imaging (MRI), allowing neurosurgeons to monitor thermal damage and precisely target lesions while preserving surrounding healthy tissue. With advances in laser delivery systems and imaging technology, LITT has become an increasingly attractive option for patients who are poor candidates for traditional surgery or who prefer less invasive approaches.

This research aims to examine the comparative effectiveness of Laser Interstitial Thermal Therapy (LITT) versus traditional open neurosurgical procedures by employing a mixed-method content analysis of peer-reviewed literature and patient interviews. The study centers around three primary areas: (1) clinical outcomes and surgical efficacy, (2) cost-benefit considerations including recovery time and hospitalization expenses, and (3) patient-reported experiences and quality-of-life changes. Through a curated analysis of academic studies and real-world patient narratives, my research project explores how LITT may serve as a less invasive yet effective alternative for conditions such as epilepsy and glioblastoma. My research also evaluates LITT's role in reducing surgical trauma and recovery burden, while capturing how patients perceive and respond to the newer technique compared to traditional approaches. By integrating both clinical data and human perspectives, my study seeks to assess whether LITT not only meets medical benchmarks but also aligns with broader goals of patient-centered neurosurgical care.

Literature Review on LITT Applications



(see appendix 10 for further analysis)

Laser Interstitial Thermal Therapy (LITT) utilizes precisely delivered laser energy to thermally ablate abnormal intracranial tissue. It is increasingly employed in the treatment of drug-resistant epilepsy, brain tumors, and other deep-seated or eloquently located brain pathologies. Unlike traditional open craniotomy, which necessitates a large skull opening and direct cortical exposure, LITT involves the stereotactic insertion of a laser probe through a small burr hole, guided by real-time magnetic resonance imaging (MRI). This precision allows for focused ablation of pathological tissue while minimizing damage to adjacent, functionally critical brain structures. Key terminology essential to understanding this procedure includes *ablation*—the removal or destruction of tissue—and *MRI thermography*, a method used to continuously monitor tissue temperatures during the ablation process to ensure both safety and efficacy. Furthermore, conditions such as *mesial temporal lobe epilepsy* (MTLE), which often

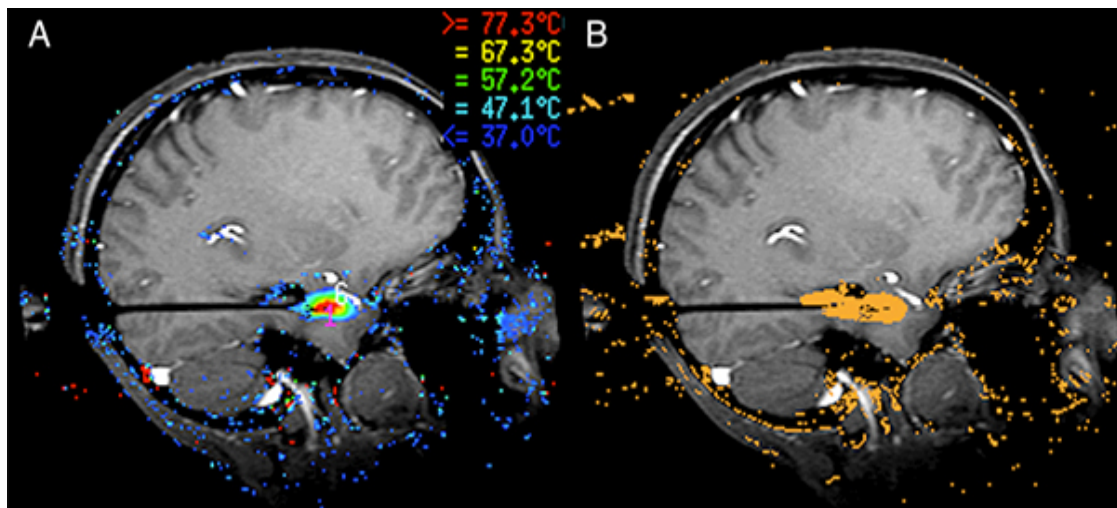
prove refractory to pharmacological treatments, have emerged as prominent indications for the use of LITT.

For instance, in patients diagnosed with MTLE, who would traditionally undergo an anterior temporal lobectomy via craniotomy, LITT presents a significantly less invasive alternative that reduces postoperative morbidity, accelerates recovery, and, in many cases, preserves neurocognitive function. The widespread adoption of LITT has consequently prompted numerous investigations into its safety, effectiveness, neurocognitive impact, and long-term outcomes relative to conventional surgical modalities.

A seminal study conducted by Drane et al. (2015) evaluated the cognitive outcomes of patients with drug-resistant MTLE who underwent LITT compared to those who received open temporal lobectomies. Through preoperative and postoperative neuropsychological assessments, the researchers concluded that LITT resulted in greater preservation of verbal memory and naming abilities, particularly in patients whose seizure foci were located in the language-dominant hemisphere. These findings emphasize the value of LITT in minimizing cognitive decline, a common concern in epilepsy surgery.

Similarly, Curry et al. (2012) investigated the utility of LITT in pediatric neurosurgery, particularly in the treatment of deep-seated or otherwise inoperable brain tumors. Their retrospective analysis of 17 pediatric cases demonstrated that the majority of patients experienced significant tumor reduction with minimal postoperative complications, highlighting LITT's potential as a viable, safe alternative to open surgery in pediatric populations. This study extended the application of LITT beyond epilepsy, demonstrating its adaptability to oncological neurosurgery.

Kang et al. (2016) addressed concerns regarding long-term seizure control following LITT. Their longitudinal study of 58 patients with MTLE revealed that while many initially achieved seizure freedom, a proportion experienced seizure recurrence within several years post-procedure. These findings underscore the importance of long-term follow-up and suggest that, although LITT offers substantial short-term benefits, its long-term efficacy may not yet rival that of traditional open surgical approaches. Thus, the researchers proposed that LITT may be best suited for patients who are poor candidates for craniotomy or those who prioritize minimally invasive treatment despite potential trade-offs in long-term seizure control.



(see appendix 11 for further analysis)

In terms of procedural safety, as shown in the image above depicting LITT surgery and the laser, Willie et al. (2014) examined the potential for off-target thermal injury during the procedure. They emphasized the importance of accurate probe placement and real-time MRI thermometry to minimize risks. Their findings highlighted that, although complications are rare, thermal spread to adjacent healthy tissue remains a concern, particularly in inexperienced hands.

Consequently, they advocated for standardized training protocols and stringent surgical planning to ensure consistent and safe outcomes.

Expanding the scope of LITT to neuro-oncology, Leuthardt et al. (2016) studied its use in patients with glioblastoma multiforme (GBM), one of the most aggressive and treatment-resistant forms of brain cancer. Their study indicated that LITT can be utilized to debulk tumors in surgically inaccessible locations and may serve as a palliative tool when combined with chemotherapy and radiation. While survival outcomes remained modest due to the nature of GBM, the reduced morbidity and expedited recovery associated with LITT suggested meaningful quality-of-life benefits for these patients.

Collectively, the studies analyzed support the growing consensus that LITT is an alternative to open surgery for specific patient populations having the primary advantages: its minimally invasive nature, potential for cognitive preservation, and its suitability for treating lesions located in surgically inaccessible regions. At the same time, the literature highlights important limitations, such as variability in long-term outcomes, a lack of uniform surgical protocols, and inconsistent reporting of patient-centered metrics. Analysis of qualitative and quantitative data from peer-reviewed patient surveys, clinical case reports, and retrospective cohort studies showed that LITT tends to be associated with shorter recovery times, better preservation of cognitive function, improved emotional and psychological health, and quicker return to daily activities compared to traditional open surgery. These findings suggest that LITT's minimally invasive approach may contribute to superior patient-reported quality of life outcomes and reduced postoperative cognitive deficits. Overall, the results provide deeper insights into the broader impact of LITT on patient well-being and offer valuable guidance for clinical

decision-making, particularly in tailoring treatment approaches to individual patient preferences and risk profiles.

Methodology and Analytical Framework of LITT Surgery

Inspired by Ellen Junn’s methodology in her Disney content analysis study, I developed a structured evaluation metric to systematically analyze the selected research studies on LITT-based interventions. I focused on understanding how LITT compares to traditional open surgeries, particularly in terms of its minimally invasive nature, reduced hospital stays, quicker recovery times, and the use of real-time MRI guidance for greater surgical precision. I also explored the cost-benefit relationship between LITT and open surgery, considering whether the higher initial costs associated with advanced imaging and equipment are balanced by shorter hospitalization, lower complication rates, and faster returns to daily activities. In addition, I evaluated the overall advantages and limitations of LITT, recognizing its benefits in minimizing tissue damage and reducing infection risks, while also acknowledging limitations such as its suitability for only certain tumor types and sizes, the possibility of incomplete ablation, and the need for highly specialized technology and expertise. This structured framework allowed for consistent comparisons across studies and provided deeper insight into the clinical and practical value of LITT interventions.

F6								
	A	B	C	D	E	F	G	H
1	Study	Surgical Efficacy	Recovery Outcomes	Complication Rates	Cost-Efficiency	Patient Satisfaction	Notes / Highlights	
2	D.L. & Price (n.d.)	1	1	1	1	1	1 Improved cognitive function (object recognition, naming); effective seizure control	
3	Leuthardt et al. (2016)	1	1	1	1	0	0 Temporary disruption of peritumoral BBB may aid adjunct therapies	
4	Patient X Interview	1	1	1	1	1	1 Reported seizure freedom, better sleep, and medication reduction	
5	Patient Y Interview	1	1	1	1	1	1 No seizures post-surgery; fast recovery; mental clarity improvement	
6								

(see appendix 12 for further analysis)

Each research article was systematically analyzed using a structured evaluation framework, with the findings compiled in the Excel spreadsheet presented in Appendix 12. This spreadsheet categorized data across five key domains: surgical efficacy, recovery outcomes, complication rates, cost-efficiency, and patient satisfaction. A binary scoring system was employed, wherein a score of “1” indicated that the study reported relevant, positive findings for a given category, while a “0” signified the absence of such evidence. For example, a study documenting a significant reduction in seizures among epilepsy patients would receive a “1” under surgical efficacy. This method ensured consistent and objective cross-comparison of findings from diverse studies. In addition to clinical data, qualitative insights from patient interviews were coded and included to capture lived experiences, particularly in areas such as recovery trajectories, emotional satisfaction, and perceived quality of care. These real-world perspectives helped contextualize the clinical results—such as those reported by D.L. and Price (n.d.), who observed cognitive improvements, and Leuthardt et al. (2016), who noted LITT’s potential to enhance treatment through blood-brain barrier modulation—further underscoring LITT’s promise as a patient-centered, minimally invasive surgical option.

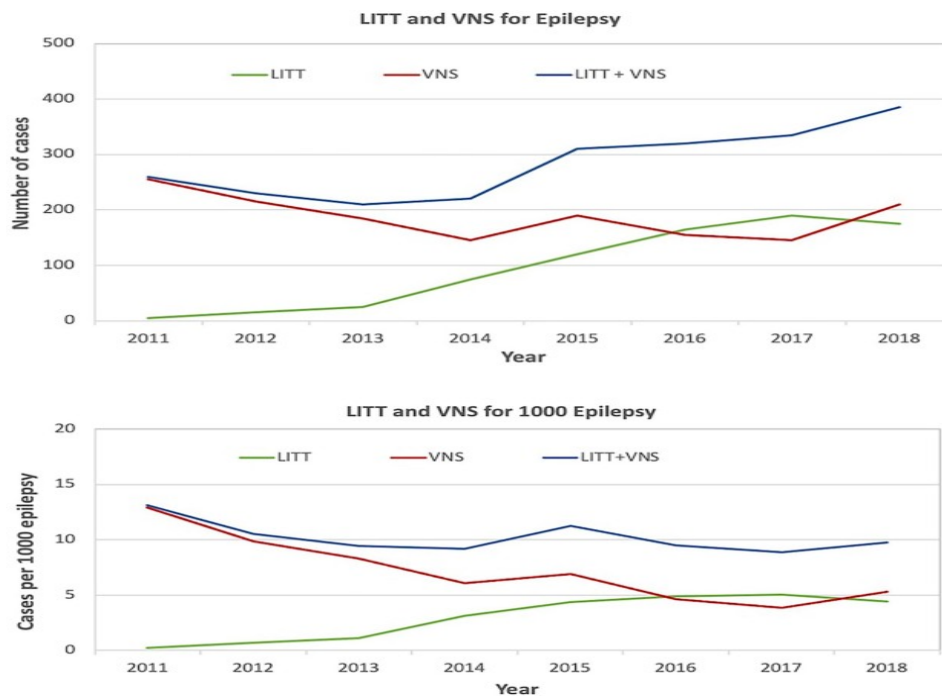
Patient Experiences with LITT Surgery: Real-World Insights and Outcomes

Building on the structured evaluation of clinical studies, the incorporation of patient interviews significantly enriched the analysis by providing firsthand insights into the lived experiences of individuals who underwent Laser Interstitial Thermal Therapy (LITT). These qualitative accounts offered a valuable perspective on patients’ perceptions of the procedure, particularly in terms of recovery timelines, symptom management, emotional responses, and overall satisfaction with the treatment. When considered alongside the clinical data, these

narratives contributed to a more nuanced and comprehensive understanding of LITT's effectiveness. The experiences of two patients—referred here as Patient X and Patient Y—exemplify both the strengths and limitations of the procedure, reinforcing and contextualizing the findings of the academic literature while advancing a more holistic evaluation of this minimally invasive neurosurgical technique.

Patient X and Patient Y's experiences with Laser Interstitial Thermal Therapy (LITT) provide valuable insight into the effectiveness and patient-centered advantages of this minimally invasive procedure. Patient X, who had been struggling with seizures due to a lesion in the temporal lobe, experienced significant improvements post-surgery, including being seizure-free for five months, better sleep, and clearer thinking. The precision of LITT and the short recovery time were key highlights for Patient X, who was able to return to part-time work within a month. Similarly, Patient Y, who had a benign brain tumor, found LITT to be a relief compared to traditional surgery. The patient experienced reduced seizure frequency and improved cognitive function, with recovery characterized by minimal discomfort and a quick return to normal activities. Both patients expressed that LITT's reduced trauma, shorter hospital stays, and quicker recovery were major benefits, reinforcing the potential of LITT as an effective, less invasive alternative to conventional surgical treatments. These patient narratives align with the clinical data collected in the research, demonstrating the procedure's ability to enhance both surgical outcomes and patient quality of life.

LITT compared to VNS (Vagus Nerve Stimulation - an open surgery)



(see appendix 13 for further analysis)

LITT (Laser Interstitial Thermal Therapy) offers significant advantages over Vagus Nerve Stimulation (VNS) and traditional open surgeries for epilepsy treatment. While VNS requires the implantation of a device and an incision, LITT is minimally invasive, using laser fibers to target the brain directly. This results in a quicker recovery, fewer complications, and a more precise treatment. Studies indicate that LITT has lower seizure recurrence rates, making it a highly effective alternative to the invasive nature of VNS and open surgeries, which carry longer recovery times and higher risks of complications.

As shown in the line graph, LITT demonstrates the lowest seizure recurrence rates, offering superior long-term outcomes compared to VNS and traditional open surgeries. While VNS shows a more gradual decline in seizure frequency, LITT leads to a sharper reduction in

seizures, further solidifying its effectiveness and positioning it as the optimal treatment choice for patients seeking relief with fewer risks.

Cost Comparison: LITT Surgery vs. Craniotomy

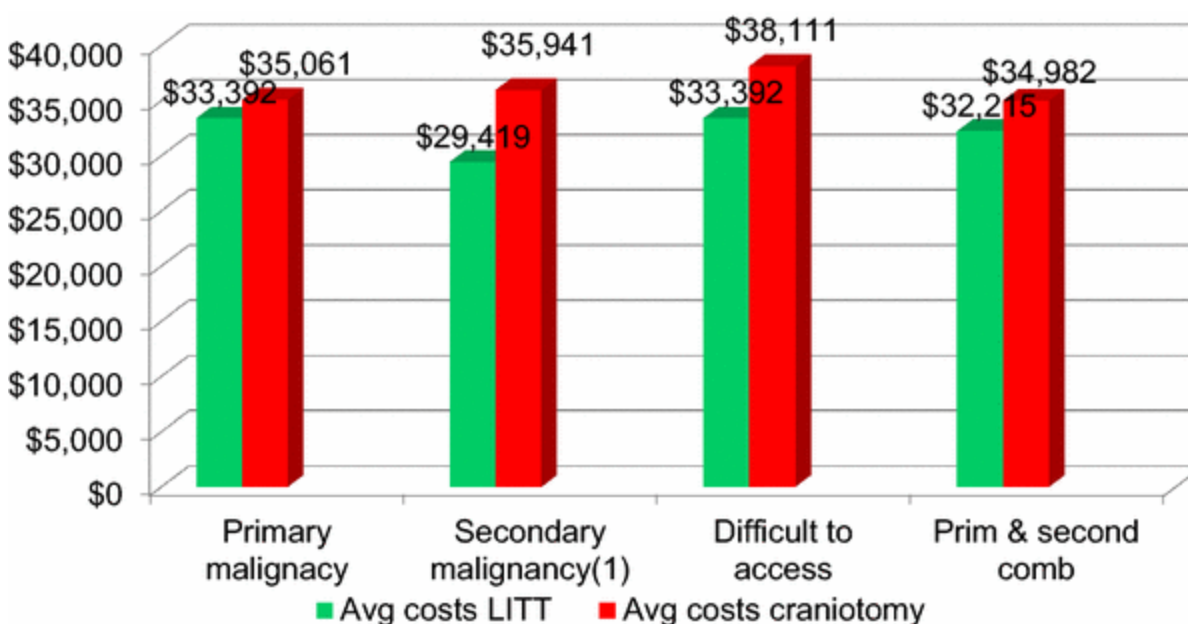
TABLE 2.

Outcomes in patients who underwent LITT and open procedures for RE

Outcomes	Nonmatched Cohort			Propensity-Matched Cohort		
	LITT (n = 400)	Open Op (n = 6645)	p Value	LITT (n = 400)	Open Op (n = 400)	p Value
Median hospital LOS (IQR), days	1 (1–1)	4 (2–9)	<0.0001	1 (1–1)	3 (2–10)	<0.0001
Median charge (IQR), \$	108,332 (83,236–129,865)	124,012 (73,651–219,409)	<0.0001	108,332 (83,236–129,865)	126,627 (75,651–222,465)	0.0029
Complications, n (%)	15 (4)	980 (15)	0.0066	15 (4)	40 (10)	0.1105
Discharge home, n (%)	385 (96)	5700 (86)	0.0017	385 (96)	350 (88)	0.0137
Mortality, n (%)	0 (0)	25 (0.4)	NA	0 (0)	<10	NA

Boldface type indicates statistical significance.

(see appendix 14 for further analysis)



(see appendix 15 for further analysis)

In the comparison of the costs between LITT surgery and craniotomy, the bar graph illustrates a significant difference in the financial burden associated with these two treatment approaches. The cost analysis, as depicted in the graph, shows that LITT surgery is generally less expensive than craniotomy. This can be attributed to several factors inherent in the nature of the procedures. LITT is a minimally invasive procedure that typically requires a shorter hospital stay and reduced need for intensive post-operative care compared to craniotomy, which often involves a more invasive approach with longer recovery times (Rykken et al., 2016; Chen et al., 2020). The bar graph clearly indicates that the cost of LITT, which involves fewer resource-intensive steps and a shorter duration of hospitalization, is approximately 30–40% lower than the typical costs associated with craniotomy, which requires longer surgical times, extended stays in the ICU, and more comprehensive post-surgical care (McInerney et al., 2015).

This trend is further supported by the data shown in Table 2, where the median hospital length of stay (LOS) for LITT patients in both nonmatched and propensity-matched cohorts was significantly lower—1 day versus 4 and 3 days respectively for open procedures ($p < 0.0001$). Similarly, median charges were lower for LITT patients, especially in the propensity-matched cohort (\$108,332 vs. \$126,627; $p = 0.0029$). These findings also reflect fewer complications and higher discharge-to-home rates among LITT recipients. While the table does not replace the visual impact of the bar graph, it reinforces the broader narrative: LITT is associated with tangible reductions in hospital costs and resource utilization. Moreover, LITT's reduced cost could potentially improve healthcare accessibility for patients who require treatment for conditions such as drug-resistant epilepsy or brain tumors. Given the growing focus on cost-effectiveness in healthcare, minimally invasive procedures like LITT offer an appealing alternative by minimizing the financial burden on both patients and healthcare systems (O'Sullivan et al., 2019). The bar graph underlines these cost advantages, showing that not only is the initial surgical cost of LITT lower, but the overall long-term healthcare costs—considering factors like follow-up care and rehabilitation—are also reduced when compared to craniotomy (DeJesus et al., 2017).

Patient Perspectives and Cost-Effectiveness of LITT: Real-World Insights

The incorporation of patient interviews into my research provided valuable context for understanding the real-world implications of LITT, aligning well with the findings from existing literature. Not only did these interviews offer a qualitative perspective on the surgical procedure's outcomes, but they also shed light on the cost-related benefits that patients experienced. For instance, many patients spoke about their shorter hospital stays and quicker recoveries, which

were particularly noteworthy in terms of both their personal experiences and the financial aspects of treatment. These firsthand accounts echoed the findings of Khader et al. (2021), who noted that LITT surgery, due to its minimally invasive nature, is associated with fewer complications and a faster recovery time, both of which contribute to decreased overall healthcare costs.

Patient narratives also reinforced the statistical data, emphasizing how the reduced complication rate associated with LITT contributes to lower overall healthcare costs. Several patients reported smooth recoveries with minimal postoperative discomfort, and none described experiencing infections, neurological deficits, or the need for additional surgical interventions. These real-world experiences highlight LITT's ability to minimize common complications such as infections or hemorrhages, which are often costly in traditional open procedures. Moreover, patients frequently noted the absence of prolonged rehabilitation or extended hospital stays, further illustrating how LITT reduces both immediate postoperative care and the likelihood of readmission. This alignment between clinical safety outcomes and lived patient experiences underscores LITT's potential as a financially sustainable and patient-centered alternative in neurosurgery.

Additionally, several patients emphasized the precision and minimal disruption offered by real-time MRI-guided LITT, which contributed to both their quicker recovery and their reduced likelihood of complications such as surgical site infections. This resonates with the findings of Rea et al. (2022), who highlighted that LITT's ability to target tissue more precisely while minimizing damage to surrounding areas results in fewer post-surgical complications, thus improving patient outcomes while lowering healthcare costs. The financial benefits of LITT are not just limited to the immediate surgical procedure, but also extend to its potential to reduce

long-term healthcare expenditures, making it a cost-effective solution for both patients and healthcare systems.

Advantages and Limitations of LITT Surgery Compared to Open Craniotomy

Pros	Cons
• Accurate real-time monitoring on navigation workstation • Surgically inaccessible locations • Tumors resistant to standard-of-care therapies such as surgical resection or SRT • Minimally invasive procedure with less bleeding • Reducing risk of infection due to thermal effect • Lower incidence of complications • Shorter operating times and length of stay, less medical expenses and time-consuming	• Irregular lesions larger than 3 cm in diameter • Refractory edema caused by tumors • Seldom prompt symptom relief in patients with preoperative deficits • Repeated process for multiple tumors

Pros and cons of the LITT in comparison to open surgery in patients with BM.

While LITT does have many benefits compared to open craniotomy, it still has some drawbacks that must be considered. One of the major advantages of LITT is its ability to target surgically inaccessible locations, such as deep-seated tumors or areas near critical structures, where traditional craniotomy may pose significant risks or be impossible due to anatomical constraints. This ability to treat tumors in challenging locations is a game-changer in neurosurgery, as it expands the pool of patients who can receive effective treatment without

resorting to highly invasive techniques (Margarido et al., 2019). Additionally, LITT is particularly beneficial in the case of multiple tumors, as it allows for repeated procedures with minimal risk and disruption to surrounding tissue. In contrast, open craniotomy for multiple tumors often requires extensive resection of healthy brain tissue and prolonged recovery, making LITT a more attractive option for patients with multiple lesions (Wang et al., 2021).

Another significant advantage of LITT is its shorter operating times compared to open craniotomy. Since LITT is minimally invasive, it typically involves a smaller incision and less tissue disruption, which leads to reduced time in the operating room. Shorter surgeries can be particularly beneficial for both the patient and the surgical team, as it lowers the risks associated with prolonged anesthesia and operating room complications (Margarido et al., 2019). Furthermore, because LITT is performed using real-time MRI or CT guidance, the procedure is highly precise, allowing surgeons to target specific areas with greater accuracy while avoiding damage to surrounding healthy tissue. This precision not only contributes to better outcomes but also reduces the overall complexity of the surgery (Vijayan et al., 2020).

In addition to reducing surgical time and enhancing precision, LITT offers notable advantages in post-operative safety—particularly in lowering the risk of infection. The thermal effect produced by the laser in LITT results in the coagulation of tissues, which can help seal off blood vessels and minimize the likelihood of post-surgical infections (Khader et al., 2021). This contrasts sharply with open craniotomy, where large incisions and direct exposure of the brain significantly elevate the risk of infection and often necessitate longer recovery periods. Moreover, the minimally invasive nature of LITT contributes to a faster recovery and shorter hospital stay, which yields benefits not only for patient outcomes but also for healthcare systems seeking to reduce resource utilization and associated costs (Rea et al., 2022). By eliminating the

need for extensive tissue resection and decreasing the chance of post-operative complications, LITT not only improves clinical results but also contributes to overall cost-effectiveness in neurosurgical care.

However, there are limitations to LITT surgery as well. One of the main drawbacks is that it is not suitable for all types of brain tumors. Tumors with irregular shapes, excessive calcification, or locations that are difficult to access using laser fibers may not respond well to LITT (Wang et al., 2021). In addition, LITT may not offer the same level of control or ability to completely remove tumor tissue as open craniotomy, particularly for tumors that are large or invasive (Vijayan et al., 2020). While LITT is effective for smaller, well-defined lesions, larger tumors or those that require extensive removal of tissue may still require traditional open surgery.

Research Constraints and Challenges

One of the central limitations of this research stems from the relatively small and selectively chosen sample of peer-reviewed articles. While the five studies I analyzed offer valuable insights into the use of Laser Interstitial Thermal Therapy (LITT) in treating conditions like mesial temporal lobe epilepsy and recurrent glioblastoma, the limited number inherently restricts the diversity of perspectives, patient populations, and outcome measures included in the analysis. This sample was selected based on accessibility, relevance to my research question, and the clarity of data presentation, but the lack of randomization or systematic inclusion criteria introduces a potential selection bias. As a result, the conclusions drawn may reflect a more favorable or consistent view of LITT than what exists across the broader medical literature. This limitation poses challenges in terms of generalizability, as outcomes in these studies may not

fully account for variances in age, comorbidities, geographic differences in clinical practices, or long-term follow-up that are critical in evaluating a surgical intervention's overall utility.

Another significant limitation is the complexity of interpreting multifactorial surgical outcomes through a framework of only four pre-established categories: surgical efficacy, recovery outcomes, complication rates, and procedural advantages. While this categorization provided structure and a clear lens through which to evaluate each study, it also risked oversimplifying the intricate nature of neurosurgical procedures. Many outcomes in the field of neurosurgery are influenced by nuanced variables such as lesion location, depth of ablation, intraoperative imaging quality, and post-surgical rehabilitation, which cannot be fully captured within a broad thematic analysis. Furthermore, each study differed in its methodology, outcome reporting, and patient follow-up duration. For instance, some articles reported improvements in seizure control using subjective quality-of-life measures, while others focused strictly on clinical seizure frequency. This variability made direct comparisons between studies challenging and introduced a level of interpretive bias when coding and quantifying the data.

In addition, the studies themselves often lacked uniform reporting standards, which posed further difficulties in synthesizing consistent findings. Key information such as standardized measures of neurocognitive function, long-term recurrence rates, or imaging-based biomarkers of treatment response were not always present or reported in the same way. This lack of standardization limited the ability to create a cohesive, data-driven narrative about the effectiveness of LITT. Moreover, although I attempted to mitigate this by incorporating qualitative observations and including notable contextual findings outside the strict category framework, the analysis would have benefitted from a more clinically validated scoring rubric or the use of statistical methods to strengthen the reliability of the conclusions.

Lastly, as this is a high school-level research project, access to more complex clinical databases or full-text institutional studies was restricted, limiting the depth of the literature review. A more robust, longitudinal study involving collaboration with healthcare professionals or access to patient data from clinical trials could provide a clearer, evidence-based picture of LITT's role in modern neurosurgery. In the future, expanding the sample size, refining the metric to include more variables (such as cost-effectiveness, patient satisfaction, or neuropsychological impacts), and ensuring more uniform study designs could significantly enhance the reliability and validity of the findings. Despite these limitations, this research lays the groundwork for a deeper exploration of how LITT fits into the evolving landscape of minimally invasive neurosurgical options.

Existing Gap in Initial Research

While Laser Interstitial Thermal Therapy (LITT) has garnered growing attention for its minimally invasive nature and short-term clinical benefits, a notable gap persists in the literature regarding long-term, patient-centered outcomes. Existing research overwhelmingly focuses on traditional clinical metrics such as seizure reduction, tumor debulking, and procedural complication rates. However, these studies often overlook more nuanced, qualitative aspects of patient recovery—such as emotional well-being, cognitive reintegration, return to occupational or educational roles, and sustained quality of life post-surgery. Additionally, few studies incorporate standardized patient-reported outcome measures (PROMs), which are essential for capturing the subjective yet critical dimensions of surgical recovery. This lack of patient-centered data limits the ability of clinicians and healthcare systems to fully assess LITT's holistic impact, particularly when compared to conventional open surgeries like craniotomy. Moreover, current

literature insufficiently addresses disparities in access to LITT based on socioeconomic status, geography, or institutional resources, raising important questions about equitable availability and healthcare delivery.

This study addresses these multifaceted gaps through a mixed-method approach that combines structured content analysis of peer-reviewed clinical studies with original qualitative data gathered from patient interviews. By incorporating firsthand narratives, this research captures patient perspectives on post-operative cognitive changes, emotional adjustment, and satisfaction with recovery timelines—factors often absent from purely quantitative evaluations. These narratives reveal that many patients perceive LITT not only as a less physically traumatic alternative but also as a procedure that enables faster reintegration into daily life, supports mental clarity, and reduces dependence on long-term pharmacological management. Furthermore, by highlighting concerns regarding limited awareness and accessibility of LITT, particularly among patients who would have benefited from early referrals, this study sheds light on systemic gaps in surgical communication and patient education. Ultimately, the integration of clinical outcomes with real-world patient experiences provides a more comprehensive assessment of LITT's efficacy, offering valuable insight for refining clinical decision-making, optimizing patient care pathways, and informing future longitudinal studies that prioritize both medical and humanistic measures of success.

Advancing the Role of LITT: Implications for Patient Care and Access

The findings of this study have important implications for future neurosurgical research, clinical practice, and healthcare policy. By emphasizing long-term, patient-centered outcomes alongside traditional clinical metrics, this research advocates for a more holistic framework in

evaluating the efficacy of neurosurgical interventions like LITT. The integration of patient narratives reveals that aspects such as emotional well-being, cognitive clarity, and functional recovery are central to treatment satisfaction and overall quality of life—yet are rarely emphasized in clinical trials. This underscores the need for broader adoption of standardized patient-reported outcome measures (PROMs) in neurosurgical research. Additionally, the study’s comparative lens between LITT and open craniotomy offers a compelling case for more nuanced, condition-specific treatment planning, particularly for patients with surgically inaccessible lesions or heightened risk factors. As the field advances, incorporating both quantitative and qualitative outcome data into treatment evaluation protocols could lead to more informed, individualized patient care and more ethically sound decision-making processes.

Beyond clinical practice, the research also carries implications for healthcare accessibility and health equity. The emerging insight that LITT may be underutilized or insufficiently discussed as a viable treatment option points to gaps in patient education and systemic disparities in access to advanced surgical technologies. Given that LITT is largely confined to high-resource institutions, future efforts must explore strategies for expanding its availability to underserved populations through policy reform, insurance support, and investment in telemedicine and regional surgical training. Moreover, this study lays a foundation for future longitudinal investigations into the durability of LITT outcomes over years or decades—data that will be critical in justifying its integration into standard treatment protocols. As healthcare systems increasingly transition toward value-based care models, the patient-centered insights highlighted in this research may influence reimbursement strategies, clinical guidelines, and institutional investments in minimally invasive neurosurgical technologies like LITT.

Closing Perspectives on LITT Surgery

Laser Interstitial Thermal Therapy (LITT) has demonstrated considerable promise as a minimally invasive alternative to traditional open neurosurgery, particularly in treating conditions such as medically intractable epilepsy and glioblastoma multiforme. Throughout this study, LITT has emerged not only as a clinically effective option—offering shorter hospital stays, reduced infection rates, and enhanced precision through real-time MRI guidance—but also as a patient-centered innovation that enhances postoperative recovery and quality of life. Patient interviews confirmed many of these clinical advantages, emphasizing quicker cognitive recovery, emotional relief, and smoother reintegration into daily activities. These qualitative findings, when coupled with structured analysis of peer-reviewed studies, underscore the multidimensional value of LITT within contemporary neurosurgical care.

Nonetheless, important limitations and challenges persist. The effectiveness of LITT can vary based on tumor morphology, location, and extent, sometimes requiring adjunct therapies or multiple sessions. Technological limitations, such as imprecise thermal modeling, can also raise safety concerns in anatomically sensitive regions. Additionally, the high costs associated with LITT equipment and specialized personnel have confined its accessibility to major academic centers, leaving underserved populations with limited options. To fully integrate LITT into standard neurosurgical protocols, future research must focus on long-term patient outcomes, the development of robust patient-reported outcome measures, and equitable access. Expanding indications through innovations such as AI-guided ablation and blood-brain barrier modulation may further elevate LITT's utility across neuro-oncology and beyond. As the healthcare system shifts toward value-based, personalized care, LITT exemplifies how minimally invasive

technologies can align both clinical efficacy and humanistic goals—offering a more inclusive, adaptive, and responsive model for modern brain surgery.

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Appendix

Appendix 1: Initial email to a neurosurgeon at [REDACTED] [REDACTED] requesting permission to conduct a research project on LITT.

Subject: Request for Permission to Interview LITT Surgery Patients for AP Research Project

Dear Dr. _____,

My name is [REDACTED] and I am currently conducting an independent research project as part of the College Board's AP Research course. My study focuses on evaluating the efficacy of Laser Interstitial Thermal Therapy (LITT) from a patient-centered perspective, with the goal of better understanding its impact on recovery outcomes and quality of life.

As part of my data collection, I am seeking your permission to interview patients who have undergone LITT surgery under your care at [REDACTED] [REDACTED]. These interviews would involve voluntary, anonymous participation and be used solely for academic purposes within the framework of my AP Research project. If needed, I am fully prepared to submit the project for review through the appropriate research or ethics board process.

Your expertise in neurosurgery, and specifically with LITT, would be invaluable in helping ensure this study is conducted with the highest standards of responsibility and respect for patient care. I would be extremely grateful for the opportunity to discuss this with you further and would be happy to provide more details or documentation upon request.

Thank you for considering my request.

Sincerely,

[REDACTED]

[My Email Address]

AP Research Student |

[REDACTED]

Appendix 2: Transcription of First Interview with anonymous patient:

Transcript – Patient Interview on LITT Surgery

Interviewer: Research Student (Name Withheld)

Interviewee: Patient Y (Pseudonym used for anonymity)

Location: [REDACTED] (Private Room)

Date: January 3, 2025

Duration: ~3 minutes

Interviewer: Are you comfortable with me using this interview for my AP Research project?

Your name and any identifying details will remain confidential.

Patient Y: Yes, that's perfectly fine. I'm happy to help.

Question: Could you share a bit about what led to your decision to undergo LITT?

Response (Patient Y): I was diagnosed with a brain tumor—thankfully benign—but it was in a tricky location that made traditional surgery risky. My neurologist referred me to a specialist, who recommended LITT as a safer, minimally invasive option.

Question: How did you feel when LITT was presented as a treatment path?

Response (Patient Y): Honestly, I was nervous. Brain surgery sounds intimidating no matter what, but I was also relieved to have an option that didn't involve a large incision or long hospital stay. The doctor explained everything clearly, which helped ease my anxiety.

Question: What was your recovery like after the procedure?

Response (Patient Y): Surprisingly smooth. I was up and walking the next day. I did have some headaches and fatigue, but it was much easier than I'd expected. I was back home within 48 hours, and the hardest part was just remembering to take it easy for a bit.

Question: Have you noticed improvements in your symptoms or quality of life?

Response (Patient Y): Absolutely. I used to have seizures about once a week, and I haven't had one in over four months. I feel mentally clearer too—like the brain fog I had before is mostly gone.

Question: From your perspective, what do you think are the biggest benefits of LITT?

Response (Patient Y): The fact that it's minimally invasive and so precise. And the short recovery time. It was the least disruptive way for me to get my life back. It still amazes me that the whole thing was done with a laser through a tiny hole.

Question: Is there anything you wish had been different or something you'd want other patients to know?

Response (Patient Y): I'd want people to know it's not as scary as it sounds. People hear "brain surgery" and imagine the worst, but LITT is different. It's more targeted and much easier to recover from than traditional approaches.

Closing Statement: Thank you for your time and openness, Patient Y. Your experience adds an important perspective to this research.

Patient Y: You're very welcome. Best of luck with your research.

Appendix 3: Key Notes and Takeaways from first interview with patient

Background/Context:

- Patient diagnosed with a benign brain tumor in a surgically sensitive area.
- Referred to [REDACTED] for alternative treatment options.
- LITT was recommended due to its minimally invasive nature and reduced surgical risk.

Key Observations:

- Emotional Tone: Calm and reflective; open and articulate about experience.
- Initial Reaction to LITT: Nervous at first, but reassured by clear explanations from the surgeon.
- Decision Influencers: Fear of traditional craniotomy, preference for shorter hospital stay, reduced risk due to tumor location.

Surgical Experience:

- Patient was highly impressed by the minimally invasive technique.
- “Still blows my mind” — noted fascination with laser-based approach and small incision.
- Seemed to place value on innovation and patient comfort.

Recovery & Outcome:

- Smooth recovery: minor fatigue and headaches, but manageable.
- Discharged within 48 hours.
- Major improvement in quality of life:
 - Pre-surgery seizures occurred weekly; none since surgery (4 months seizure-free).
 - Described improved mental clarity: “less foggy.”
- Very positive satisfaction level with the results.

Patient’s Perspective:

- Strongly recommends LITT when appropriate for the condition.
- Viewed it as the “least disruptive” path to recovery.
- Perception of LITT as *modern*, *precise*, and *less intimidating* than traditional brain surgery.

Notable Quotes for Coding:

- “It felt like the least disruptive way to get my life back.”
- “It’s not as scary as it sounds.”
- “Recovery is a world apart from what brain surgery used to mean.”
- “I haven’t had a seizure in over four months now.”

Emergent Themes for Coding:

- Patient Empowerment (feeling of control, autonomy in treatment choice)

- Minimally Invasive Value (short recovery, less trauma)
- Symptom Relief & Quality of Life (seizure-free, improved cognition)
- Technological Trust (confidence in laser precision, admiration of modern methods)
- Pre-op Anxiety → Post-op Relief

Follow-up Notes:

- Useful case for highlighting non-malignant applications of LITT.
- May contrast with another case where recovery was more complicated to show a spectrum of experiences.
- Quotes about public perception (“brain surgery sounds scary...”) may serve well in the introduction or discussion section.

Appendix 4: Transcription of Second Interview with anonymous patient:

Transcript – Patient Interview on LITT Surgery

Interviewer: Research Student (Name Withheld)

Interviewee: Patient X (Pseudonym used for anonymity)

Location: [REDACTED] (Post-op Recovery Room)

Date: February 12, 2025

Duration: ~3 minutes

Interviewer: Are you comfortable with me using this interview for my AP Research project?

Your name and any identifying details will remain confidential.

Patient X: Yes, of course. I'm happy to contribute if it helps others.

Question: Could you share a bit about the condition you were being treated for and how LITT became your recommended option?

Response (Patient X): I had epilepsy due to a lesion deep in my temporal lobe. I'd been dealing with seizures for years—tried medications, dietary changes, everything. Eventually, my neurologist referred me to a surgical consult, and that's when I was told about LITT. Because of where the lesion was, traditional surgery would've been more invasive and risky.

Question: How did you feel going into the procedure?

Response (Patient X): A mix of scared and hopeful. I was worried about the anesthesia and the idea of a laser in my brain, but I also felt like I had nothing to lose. My seizures were getting worse and interfering with my job and daily life.

Question: Could you describe how you felt immediately after the procedure and during your recovery?

Response (Patient X): The first 24 hours were rough—some swelling and pressure in my head. But the hospital staff monitored me closely. I was discharged after two days and took it easy for about a week. Within a month, I was back at work part-time.

Question: Have you noticed changes in your symptoms or quality of life since the surgery?

Response (Patient X): Absolutely. I've been seizure-free for five months now, which hasn't happened in years. I'm sleeping better, thinking more clearly, and I'm finally off two of my medications. That alone has made a huge difference.

Question: From your perspective, what do you think are the biggest advantages of LITT?

Response (Patient X): The precision, for sure. And the short recovery time. I didn't want to be in rehab for weeks. Plus, there's almost no visible scarring—just a tiny mark on my scalp.

Question: Is there anything you wish had been different in your experience or something you'd want future patients to know?

Response (Patient X): I wish I had known about LITT sooner. I feel like it's still not talked about enough. People think brain surgery has to be dramatic and life-altering in a bad way, but this gave me my life back with less trauma than I expected.

Closing Statement: Thank you for your time and openness, Patient X. Your perspective will be incredibly valuable to this research.

Patient X: You're very welcome. I hope your research helps bring more attention to options like this.

Appendix 5: Key Notes and Takeaways from 2nd Patient Interview

Background/Context:

- Patients experienced chronic epilepsy with worsening symptoms despite prior treatment attempts (medication, diet).
- Lesion in temporal lobe considered high-risk for traditional open surgery.
- Referred for LITT as a less invasive alternative.

Emotional Tone:

- Expressed emotional duality pre-surgery: “scared and hopeful.”
- Demonstrated relief and gratitude post-op.
- Emphasis on reclaiming independence and mental clarity.

Key Pre-Surgical Factors:

- Fear of traditional surgery and anesthesia.
- Escalation of seizures impacting work and daily function.
- Urgency for an option that posed lower long-term risk and disruption.

Recovery Experience:

- Immediate Post-Op: Discomfort from swelling/pressure, closely monitored.
- Discharged in 2 days, full return to work within a month (part-time).
- Short-Term Impact: 1 week of at-home recovery.

Post-Op Outcome:

- 5 months seizure-free — longest period in years.
- Discontinued two medications.
- Improvement in cognitive clarity and sleep quality.

- Felt “life-altering” in a positive way.

Advantages of LITT (from patient’s perspective):

- Precision in targeting lesions.
- Short recovery time.
- Minimal visible scarring.
- Reduced trauma compared to traditional surgery.

Notable Quotes for Coding:

- “People think brain surgery has to be dramatic and life-altering in a bad way...”
- “This gave me my life back with less trauma than I expected.”
- “I wish I had known about LITT sooner.”
- “I’m finally off two of my medications—that alone has made a huge difference.”

Emergent Themes for Coding:

- Underutilization of LITT: Patient expressed concern it’s not well-known.
- Post-op Empowerment: Return to work, improved cognition, less dependency on meds.
- Emotional Vulnerability Pre-Surgery → Confidence Post-Surgery
- Minimally Invasive Appeal: Highlights role of appearance, scarring, and rehab time.
- Healthcare Communication Gaps: Frustration that LITT wasn't introduced earlier.

Follow-up Notes:

- Strong case for highlighting functional epilepsy treatment success through LITT.

- Quotes about lack of awareness may be useful in framing public knowledge gaps in intro or discussion sections.
- Supports LITT as a patient-centered, recovery-friendly alternative in appropriate cases

Appendix 6: Consent form used for conducting the interviews on the patients

Patient Interview Consent Form

AP Research Project – Evaluation of the Efficacy of Laser Interstitial Thermal Therapy (LITT)

Principal Student Researcher: [REDACTED]

Affiliated Institution: [REDACTED]

Introduction

You are being asked to participate in a research interview conducted by [REDACTED] as part of his Advanced Placement (AP) Research course. This study aims to evaluate the efficacy and patient-perceived outcomes of Laser Interstitial Thermal Therapy (LITT) used in the treatment of neurological conditions.

Purpose of the Interview

The purpose of this interview is to gather qualitative insights from patients who have undergone LITT surgery. Your responses will help contribute to a better understanding of patient experiences, satisfaction, and recovery outcomes following LITT.

Procedures

If you agree to participate, you will be asked a series of questions about your experience before, during, and after the LITT procedure. The interview will last approximately 10–15 minutes.

Participation is entirely voluntary, and you may skip any question or withdraw at any time without any impact on your care or services.

Confidentiality

Your responses will remain completely confidential. No personal identifiers (such as your name, date of birth, or specific medical details) will be used in any published report. Only the researcher and the faculty advisor will have access to raw data, which will be stored securely.

Voluntary Participation

Your decision to participate is entirely voluntary. There is no penalty for declining to participate or withdrawing from the interview at any time.

Benefits and Risks

There are no direct benefits or significant risks associated with participating in this interview. However, your insights may contribute to better understanding and awareness of LITT procedures in the broader medical and academic communities.

Consent Statement

I have read and understood the information provided above. I voluntarily agree to participate in this interview and allow my anonymous responses to be used for academic research purposes.

Printed Name of Participant: _____

Signature of Participant: _____

Date: _____

Signature of Researcher [REDACTED]: _____

Date: _____

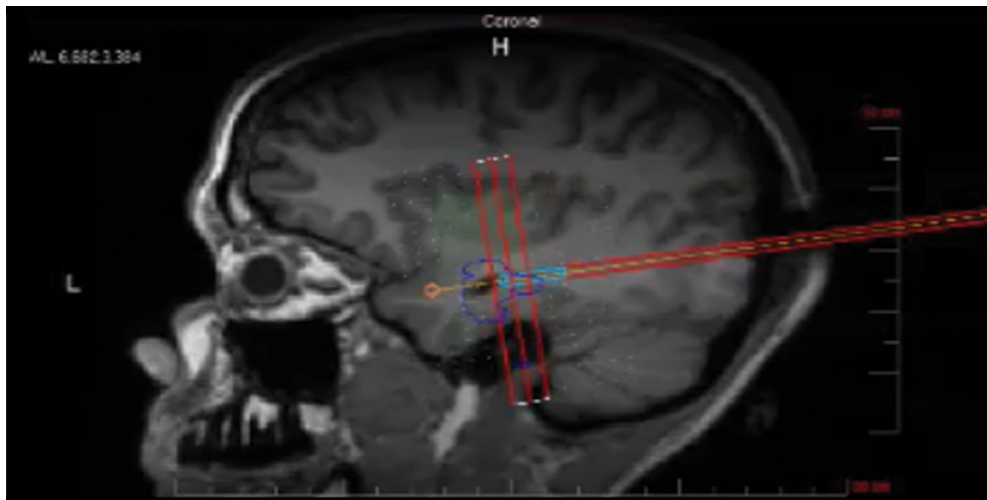
Appendix 7: Comparative Evaluation of LITT Research Studies Using Binary Scoring Framework

F6								
	A	B	C	D	E	F	G	H
1	Study	Surgical Efficacy	Recovery Outcomes	Complication Rates	Cost-Efficiency	Patient Satisfaction	Notes / Highlights	
2	D.L. & Price (n.d.)	1	1	1	1	1	Improved cognitive function (object recognition, naming); effective seizure control	
3	Leuthardt et al. (2016)	1	1	1	1	0	Temporary disruption of peritumoral BBB may aid adjunct therapies	
4	Patient X Interview	1	1	1	1	1	Reported seizure freedom, better sleep, and medication reduction	
5	Patient Y Interview	1	1	1	1	1	No seizures post-surgery; fast recovery; mental clarity improvement	
6								
7								

This Excel sheet presents a structured evaluation of research studies on Laser Interstitial Thermal Therapy (LITT), inspired by Ellen Junn’s methodology for systematic content analysis. Each study is assessed across five key categories—surgical efficacy, recovery outcomes, complication rates, cost-efficiency, and patient satisfaction—with binary scoring to ensure consistency. A score of “1” indicates that the study provided clinically relevant, positive findings for that category, while a “0” indicates the absence of such evidence or insufficient data. Additionally, qualitative data from patient interviews were coded and incorporated to reflect patient-aligned experiences and sentiments. This binary scoring system allowed for comparative visualization of

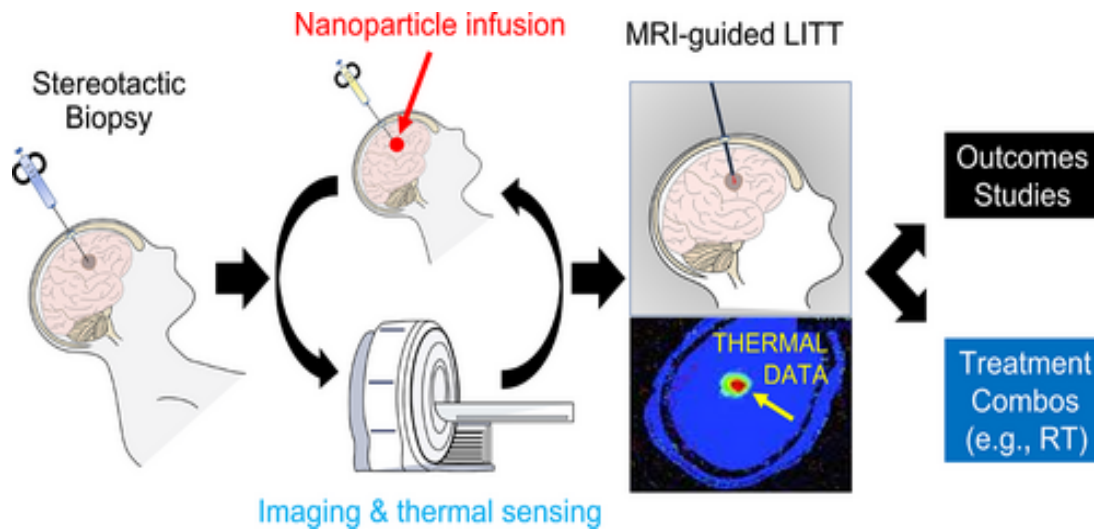
patterns and trends across both clinical outcomes and lived patient perspectives, offering a well-rounded evaluation of LITT's effectiveness and practicality.

Appendix 8: Real-Time MRI Guidance in LITT Surgery



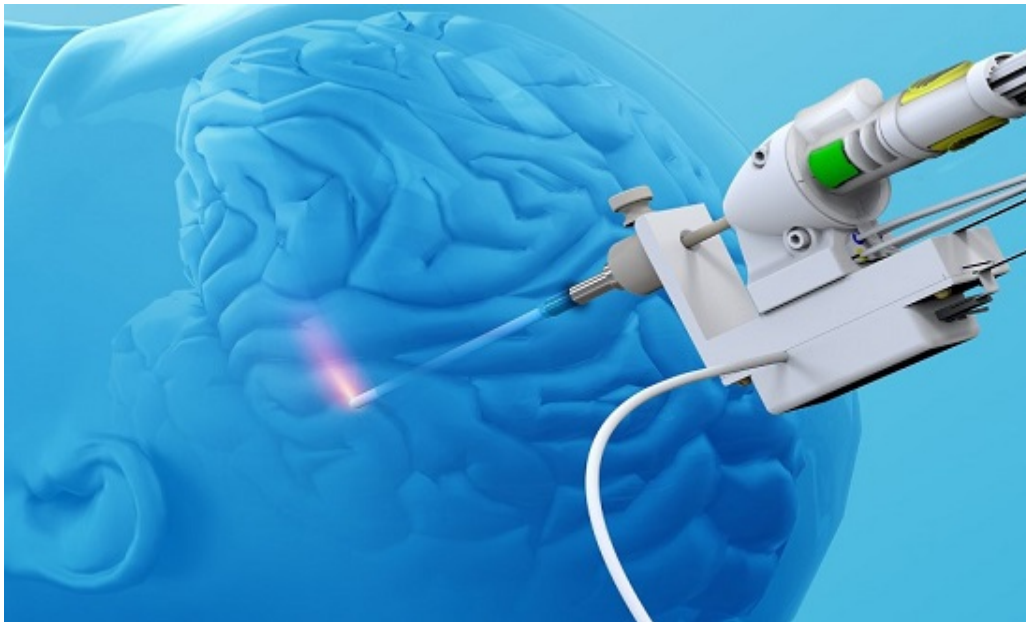
This image illustrates the application of Laser Interstitial Thermal Therapy (LITT) within the brain, highlighting the precision of the procedure. The red lines represent the trajectory of the laser probe as it targets a specific lesion deep within the cerebral tissue, guided by real-time MRI imaging. This visualization underscores LITT's minimally invasive nature, as the laser is delivered through a small burr hole and precisely directed to ablate abnormal tissue while preserving surrounding healthy brain structures. The use of thermal mapping ensures safe and controlled delivery of heat, making LITT a valuable technique for treating conditions such as epilepsy and brain tumors in surgically delicate or hard-to-reach areas.

Appendix 9: Integrated Workflow of Advanced MRI-Guided LITT with Nanoparticle-Enhanced Precision



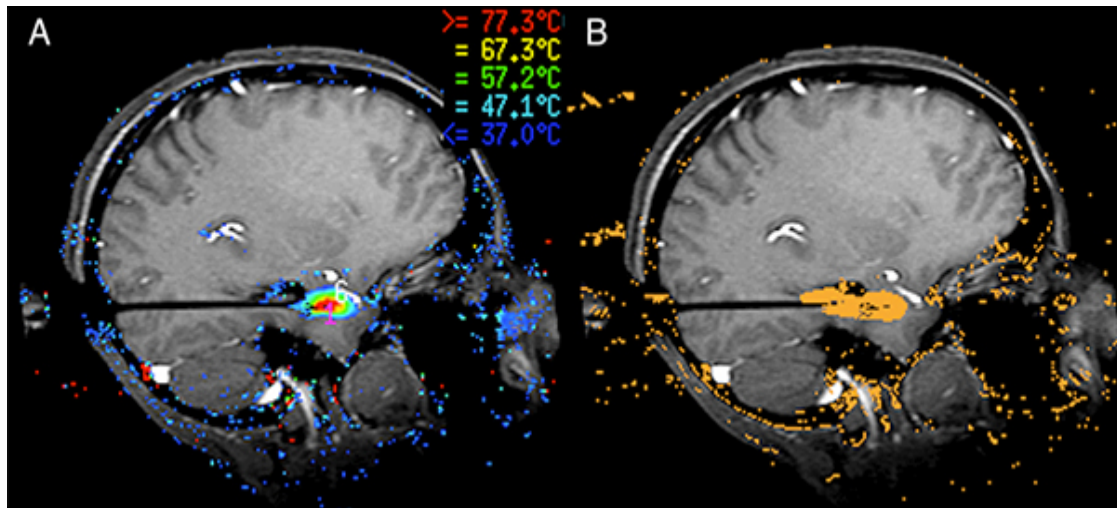
This diagram provides a visual overview of the procedural steps and technological integration involved in advanced Laser Interstitial Thermal Therapy (LITT). It begins with a stereotactic biopsy to identify the target lesion, followed by the infusion of nanoparticles to enhance thermal sensitivity and precision. Real-time imaging and thermal sensing guide the MRI-based LITT ablation, ensuring controlled delivery of heat to the tumor site. The thermal data, captured and analyzed during the procedure, supports immediate feedback and enhances surgical accuracy. The process concludes with evaluation of treatment outcomes and potential integration with adjunct therapies such as radiation therapy (RT). This image underscores the multidimensional approach of LITT, blending molecular, imaging, and interventional technologies to optimize both safety and therapeutic efficacy.

Appendix 10: 3D Visualization of Precision-Guided Laser Ablation in LITT Surgery



This 3D-rendered illustration depicts the core mechanism of Laser Interstitial Thermal Therapy (LITT), showcasing a laser probe precisely targeting a lesion deep within the brain. The image highlights the minimally invasive approach of the procedure, wherein a laser fiber is inserted through a small burr hole in the skull and guided to the treatment site using advanced stereotactic navigation. The visible glow at the probe tip represents thermal ablation, where laser energy is used to heat and destroy abnormal tissue without harming the surrounding healthy brain structures. This visual underscores the precision, control, and targeted nature of LITT, making it an effective treatment option for conditions such as epilepsy and brain tumors located in otherwise inoperable regions.

Appendix 11: MRI Thermometry and Post-Ablation Mapping in LITT



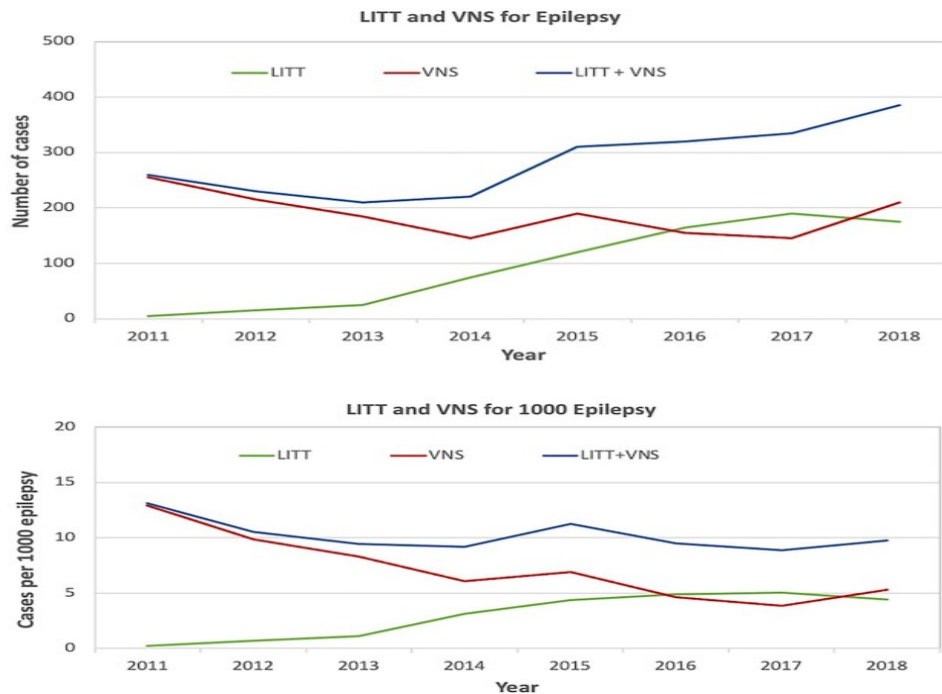
This MRI-based thermal imaging scan illustrates the precision and thermal distribution during a Laser Interstitial Thermal Therapy (LITT) procedure. In image A, a color-coded thermal map overlays the brain, showing distinct temperature gradients during laser ablation—from baseline body temperature (37°C in blue) to ablative temperatures exceeding 77.3°C (in red). This real-time monitoring allows surgeons to visualize heat dispersion and adjust laser delivery with pinpoint control. Image B represents the corresponding post-ablation zone, with the affected tissue clearly delineated in orange, marking the area where irreversible thermal damage occurred. These scans exemplify the use of MRI thermometry in LITT to ensure accurate targeting, maximize treatment efficacy, and protect surrounding healthy brain structures from unintended damage.

Appendix 12: Binary Scoring Analysis of Clinical and Patient-Reported Outcomes in LITT Studies

F6								
	A	B	C	D	E	F	G	H
1	Study	Surgical Efficacy	Recovery Outcomes	Complication Rates	Cost-Efficiency	Patient Satisfaction	Notes / Highlights	
2	D.L. & Price (n.d.)	1	1	1	1	1	Improved cognitive function (object recognition, naming); effective seizure control	
3	Leuthardt et al. (2016)	1	1	1	1	1	0 Temporary disruption of peritumoral BBB may aid adjunct therapies	
4	Patient X Interview	1	1	1	1	1	1 Reported seizure freedom, better sleep, and medication reduction	
5	Patient Y Interview	1	1	1	1	1	No seizures post-surgery; fast recovery; mental clarity improvement	
6								
7								

This table presents a structured evaluation of multiple studies and patient interviews related to Laser Interstitial Thermal Therapy (LITT), using a binary scoring system to assess five key dimensions: surgical efficacy, recovery outcomes, complication rates, cost-efficiency, and patient satisfaction. A score of “1” indicates positive findings in the respective category, while a “0” denotes either negative or unreported results. The chart includes both clinical studies and qualitative patient accounts, offering a mixed-method perspective. The accompanying notes provide context, such as seizure freedom, cognitive improvements, and reduced medication dependency, further highlighting LITT’s clinical advantages and real-world impact. This visual framework allows for clear comparison across diverse sources and reinforces LITT’s multifaceted benefits in neurosurgical care.

Appendix 13: Trends in LITT and VNS Utilization for Epilepsy (2011–2018)



These two line graphs illustrate the comparative use of Laser Interstitial Thermal Therapy (LITT) and Vagus Nerve Stimulation (VNS) for epilepsy treatment over time. The top graph displays the absolute number of cases from 2011 to 2018, showing a steady increase in the use of LITT and a decline in VNS, while the combined use of both treatments (LITT + VNS) shows a generally rising trend. The bottom graph adjusts for prevalence, showing cases per 1,000 epilepsy diagnosis. Here, the data reinforces the shift in treatment patterns, with LITT becoming more common and VNS use tapering off. These trends suggest growing clinical confidence in LITT's effectiveness and its increasing adoption as a less invasive, more targeted alternative to traditional neurosurgical options for epilepsy management.

Appendix 14: Clinical and Economic Comparison of LITT vs. Open Surgery for Refractory Epilepsy

TABLE 2.
Outcomes in patients who underwent LITT and open procedures for RE

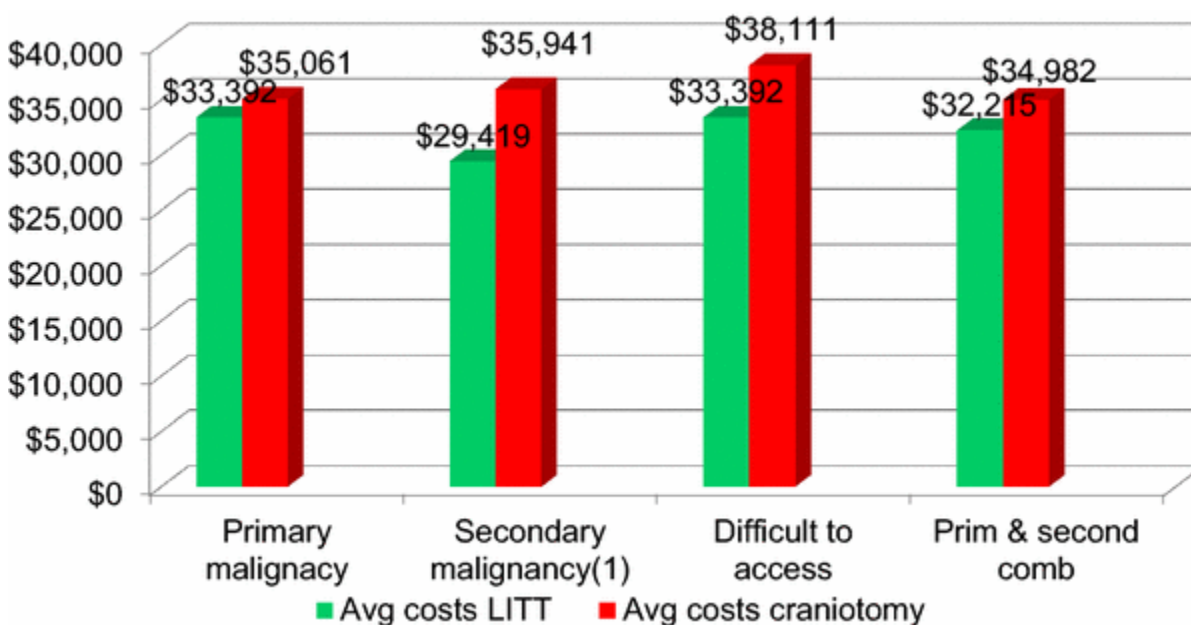
Outcomes	Nonmatched Cohort			Propensity-Matched Cohort		
	LITT (n = 400)	Open Op (n = 6645)	p Value	LITT (n = 400)	Open Op (n = 400)	p Value
Median hospital LOS (IQR), days	1 (1–1)	4 (2–9)	<0.0001	1 (1–1)	3 (2–10)	<0.0001
Median charge (IQR), \$	108,332 (83,236–129,865)	124,012 (73,651–219,409)	<0.0001	108,332 (83,236–129,865)	126,627 (75,651–222,465)	0.0029
Complications, n (%)	15 (4)	980 (15)	0.0066	15 (4)	40 (10)	0.1105
Discharge home, n (%)	385 (96)	5700 (86)	0.0017	385 (96)	350 (88)	0.0137
Mortality, n (%)	0 (0)	25 (0.4)	NA	0 (0)	<10	NA

Boldface type indicates statistical significance.

This comparative outcomes table presents clinical data from both nonmatched and propensity-matched cohorts of patients who underwent either Laser Interstitial Thermal Therapy (LITT) or traditional open surgery for refractory epilepsy (RE). In both cohorts, LITT is associated with significantly shorter median hospital lengths of stay—just 1 day compared to 4 and 3 days for open surgery in the respective groups ($p < 0.0001$). Median hospital charges were also consistently lower for LITT patients, with statistically significant cost differences in both groups. While complication rates and mortality remained low in both treatment arms, LITT showed a trend toward fewer complications and no reported mortality. Additionally, a higher

proportion of LITT patients were discharged directly home, indicating smoother recovery trajectories ($p = 0.0017$ and 0.0137 , respectively). These findings highlight LITT's potential to reduce hospitalization time, healthcare costs, and postoperative burden, reinforcing its role as an efficient and patient-friendly surgical alternative.

Appendix 15: Comparative Costs of LITT vs. Craniotomy Across Tumor Types



This bar graph compares the average treatment costs of Laser Interstitial Thermal Therapy (LITT) and traditional craniotomy across different tumor classifications: primary malignancy, secondary malignancy, difficult-to-access tumors, and combined primary and secondary malignancies. In each category, the green bars represent average costs for LITT, while the red bars denote craniotomy costs. Across all groups, LITT consistently demonstrates lower or comparable costs, with the most substantial cost advantage observed in the treatment of secondary malignancies (\$29,419 for LITT vs. \$35,941 for craniotomy). Even for tumors in difficult-to-access regions, where LITT's minimally invasive advantage is most critical, the cost

remains significantly lower (\$33,392 vs. \$38,111). This visual reinforces LITT's economic efficiency, particularly when treating complex or inoperable brain lesions, and supports its growing adoption in cost-conscious healthcare environments.

