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Patient-reported outcome and preference after craniotomy and laser interstitial thermal therapy ablation: a pilot study

Isabela Peña Pino, MD,[1] Jiri Bartek, MD,[2,3] Sharona Ben-Haim, MD,[4] and Clark C. Chen, MD, PhD[5]

[1]Department of Neurosurgery, University of Minnesota, Minneapolis, Minnesota; [2]Genome Integrity Unit, Danish Cancer Society Research Center, Copenhagen, Denmark; [3]Department of Medical Biochemistry and Biophysics, Karolinska Institute, Stockholm, Sweden; [4]Department of Neurosurgery, University of California, San Diego, California; and [5]Department of Neurosurgery, Brown University, Providence, Rhode Island

OBJECTIVE Laser interstitial thermal therapy (LITT) is a minimally invasive procedure that allows cytoreduction of brain tumors and can be considered as an alternative to craniotomy. The authors surveyed 27 patients who underwent both craniotomy and LITT during distinct stages of their oncology journey to assess patient-reported outcomes comparing both procedures.

METHODS A 9-question survey was developed and validated to assess patient-reported postoperative recovery, pain level, narcotic use, and procedure preference. The survey was administered to patients with WHO grade II–IV gliomas who underwent both craniotomy and LITT.

RESULTS The survey was reviewed by independent surgeons, patient advocates, and patients for face validity and showed > 90% intrarater agreement over time. The cohort had a mean age of 57 ± 12 years, and 78% had glioblastoma. There was no significant difference in symptomatic improvement postcraniotomy or post-LITT (30% vs 4%, $p = 0.17$). Similarly, no significance was detected in patient-reported recovery time from craniotomy (time required to return to preoperative state: mean 4.3 ± 9.1 weeks, median 2 weeks) or LITT (mean 2 ± 2.3 weeks, median 1 week; $p = 0.21$). Notably, postsurgical pain (0–10 on the visual analog scale) and need for narcotic use in the first week (yes/no) after the procedure were significantly lower post-LITT (average visual analog scale score 1.7 vs 5 points, narcotic use 4% vs 81%; $p < 0.0001$ for both comparisons). When asked which procedure they would choose—having experienced both craniotomy and LITT—surveyed patients overwhelmingly chose LITT over craniotomy (89% vs 11%, $p < 0.0001$). Of note, the patients who preferred craniotomy experienced improved neurological function postcraniotomy or suffered new deficits post-LITT.

CONCLUSIONS In this pilot study, patients reported less pain and narcotic use post-LITT relative to craniotomy and generally preferred the former procedure if given the choice. Validation of these results in future studies can help inform decision-making in clinical scenarios where there is equipoise between LITT and craniotomy.

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KEYWORDS glioma; laser interstitial thermal therapy; LITT; stereotactic laser ablation; SLA; quality of life; postoperative pain; patient preference

Stereotactic laser ablation or laser interstitial thermal therapy (LITT) is a minimally invasive surgical treatment for both intracranial and spinal disease, including drug-resistant epilepsy, radiation necrosis, and neoplasms. Relative to craniotomy, LITT is a relatively new procedure in neurosurgery. As such, the clinical indications for LITT continue to evolve. In the pediatric population, LITT has uniquely filled gaps for treatment of surgically inaccessible lesions such as hypothalamic hamartoma[1] and tuberous sclerosis hamartomas.[2] Similarly, in adults, LITT is most often used for treatment of lesions considered high risk when standard surgical approaches are considered, such as tumors involving the deep gray matter.[3] Beyond cytoreduction, LITT may have a synergistic effect with immunotherapy, and this combination is currently being explored in clinical trials (NCT03277638, NCT04187872, and NCT03341806).

In contrast to the surgical exposure required of conventional craniotomy, LITT requires an approximately 3-mm incision/burr hole, through which the laser probe is ste-

ABBREVIATIONS ICC = intraclass correlation coefficient; LITT = laser interstitial thermal therapy; PRO = patient-reported outcome; VAS = visual analog scale.

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reotactically inserted.[4] The safety profile of the procedure is comparable to that associated with stereotactic needle biopsies[5] and can be performed in conjunction with these biopsies (i.e., in the same procedure) without significant added risk.[6] From a physician's perspective, the minimally invasive nature of the procedure presents several advantages. A minimally invasive procedure generally translates into improved patient satisfaction, shortened recovery period, and the minimization of delay for subsequent systemic or radiation therapy for oncology patients.[7,8] In these contexts, LITT is increasingly explored as an alternative to craniotomy. In one study, 56% of physicians who performed LITT for oncological indications reported that LITT was performed instead of craniotomy because of patient preference, when the treating surgeon considers both treatments appropriate.[9] However, there are limited studies of patient preferences or patient-reported outcomes (PROs) after LITT.

To address this knowledge gap, we developed a questionnaire to study patient-reported postoperative outcomes and preferences. Using this questionnaire, we surveyed 27 patients who underwent both craniotomy and LITT during distinct stages of their oncology journey. In this pilot study, patients reported less pain and narcotic use post-LITT relative to craniotomy and generally preferred the LITT after having experienced both procedures.

Methods

This study was conducted at the University of California, San Diego with approval from the institution's internal review board. Inclusion criteria were as follows: > 18 years of age, diagnosis of a WHO grade II–IV glioma, English speaking, capacity for consent, and underwent both craniotomy for open resection and LITT less than 1 year apart for symptomatic tumor recurrence. Recruitment and consent for participation were completed at the postoperative visit after the second procedure. A 9-question survey was created by the lead surgeon and reviewed by independent surgeons, patient advocates, and patients for face validity. The survey tested the following outcomes: overall postoperative state (better, same, worse) after craniotomy and LITT; estimated recovery period to return to baseline condition after craniotomy and LITT (< 1 week, 1 week to < 1 month, 1–3 months, > 3 months, never); maximum level of postoperative pain within the first 72 hours (0–10 on the visual analog scale [VAS]) after craniotomy/LITT; postoperative opioid need after craniotomy and LITT (yes/no); and patient preference if they had to undergo another procedure—with both procedures as potential options (Supplemental Survey). Once enrolled, participants filled out the survey within 6 months of the second procedure. A subset of participants was administered the same survey within 1 week to assess test-retest survey validity. The clinical data collected included age, sex, histological diagnosis, tumor location, and indication for undergoing the second procedure.

Statistical analysis included qualitative descriptions as well as univariate comparisons between procedure outcomes. Fisher exact tests were used for discrete variables and Wilcoxon signed-rank tests for continuous variables. Test-retest reliability was assessed as percent intrarater agreement and by measuring internal consistency.[10] Percent intrarater agreement was calculated as identical answers over time (or within a 1-point range in the VAS, when applicable). Internal consistency was measured according to the data. For continuous and ordinal data, we calculated the intraclass correlation coefficient (ICC) for absolute single raters to determine the reliability of single raters with repeat assessments, and for absolute average raters to determine the reliability of averaging multiple raters' responses. For binary data (yes/no or two options), we calculated Cohen's Kappa value for agreement within raters (intrarater reliability) and the Fleiss Kappa value for agreement between raters (interrater reliability). Statistical significance was determined by a p value < 0.05. All statistical analyses were performed using RStudio (Posit).

Results

Questionnaire

Although there are validated PRO tools in the published literature, including the VAS and satisfaction Likert scale, we were unable to identify a single PRO tool in the literature that adequately addressed all of the goals of the study, including length of recovery, postoperative pain, narcotics use, and procedural preference. A new survey was developed in this context. A 9-question survey was initially drafted by C.C.C. and J.B. with the goal of assessing the experience of patients who underwent both craniotomy and LITT during distinct stages of their oncology journey. The domains of the questionnaire include PROs for the following: 1) postoperative recovery; 2) pain; 3) narcotics use; and 4) preference for LITT or craniotomy. The questions were then reviewed independently by a psychologist, a patient advocate, and a patient to establish face validity. The questions were then revised based on the comments of the reviewers and administered to 3 patients for survey validity. All survey questions with the exception of question 3, "Highest level of pain after open surgery (0–10 scale) in the first 72 hours," had a 100% intrarater agreement. Intrarater and interrater reliability measurements showed statistically significant ICC or Kappa values of 1, with the exception of questions 3 and 7. The ICC or Kappa could not be measured for questions 5 and 8 given the absence of variability in the data (Tables 1 and 2).

Study Cohort

A total of 27 patients were surveyed. The demographics and clinical characteristics of the study cohort are as shown in Table 3. The mean age of the study cohort was 57 ± 12 years. Thirty-three percent of the study cohort was female. All patients were symptomatic at the time of surgery. Histological diagnosis in this study cohort included glioblastoma (78%), anaplastic astrocytoma (15%), and WHO grade II astrocytoma (7%). Tumors were left-sided in 48% of patients, right-sided in 30% of patients, and midline or multifocal in 22% of patients. Seventy-four percent of the patients underwent craniotomy as the first procedure. All patients underwent their second procedure due to tumor recurrence.

TABLE 1. Survey test-retest reliability: percent intrarater agreement and reliability measures for continuous and ordinal data

Question	% Agreement	Absolute ICC	
		Single Raters	Average Raters
1. Were you better, same, or worse after the open surgery relative to immediately prior to surgery?	100%	1.00 (p < 0.0005)	1.00 (p < 0.0005)
2. Estimate the recovery period after open surgery (before you feel back to your usual self)	100%	1.00 (p < 0.0005)	1.00 (p < 0.0005)
3. Highest level of pain after open surgery (0–10 scale) in the first 72 hours	66%	0.58 (p = 0.05)	0.81 (p = 0.05)
5. Were you better, same, or worse after the laser ablation relative to immediately prior to surgery?	100%	NA	NA
6. Estimate the recovery period after laser ablation (before you feel back to your usual self)	100%	1.00 (p < 0.0005)	1.00 (p < 0.0005)
7. Highest level of pain after laser ablation (0–10 scale) in the first 72 hours	100%	0.14 (p = 0.3)	0.33 (p = 0.3)

NA = not applicable.

Survey Outcome

When assessing surgical outcomes, we observed no significant difference in symptomatic improvement post-craniotomy or post-LITT (30% vs 4%, p = 0.17). Similarly, no statistical significance was detected in patient-reported recovery time from craniotomy (mean 4.3 ± 9.1 weeks, median 2 weeks) or LITT (mean 2 ± 2.3 weeks, median 1 week; p = 0.21) (Fig. 1). Notably, postsurgical pain and need for narcotic use in the first week after the procedure were significantly lower post-LITT (Fig. 2). The average pain score after LITT was 1.7 points versus 5 points after craniotomy (p < 0.0001). Narcotic use within the first 72 hours after surgery was necessary in 4% of patients after LITT versus 81% after craniotomy (p < 0.0001). When asked which procedure they would choose—having experienced both craniotomy and LITT—89% of surveyed patients chose LITT over craniotomy (p < 0.0001) (Fig. 3). Table 4 summarizes survey outcomes. Individual patient responses can be found in the Supplemental Table.

Discussion

Evaluating the relative merits of differing surgical options forms the foundation for decision-making in neurosurgical oncology. This evaluation is shaped by medical considerations, including the critical anatomy of the lesion, the surgeon's training/experience, and the overall clinical context.[11] Although voluminous scholarly work has focused on the delicate interplay between these medical considerations in surgical decision-making, opportunities remain for incorporating the psychosocial aspects of patient perception and experience. As a first step toward this end, we surveyed patients who underwent both craniotomy and LITT at distinct stages of their oncology journey to determine whether they prefer one procedure over the other. We found that 89% of the surveyed patients preferred LITT over craniotomy, reporting less postoperative pain and narcotic use.

In considering our survey results, it is essential to note that LITT and craniotomy should not be considered interchangeable. There are clinical scenarios in which each procedure is indicated. For instance, performing LITT in a patient with a lesion causing significant mass effect can lead to catastrophic consequences.[12] In contrast, craniotomy is the gold standard treatment for such lesions.[13] Similarly, LITT treatment of a subcentimeter, seizure-causing hypothalamic lesion will more likely lead to a favorable outcome relative to craniotomy.[1] Moreover, whereas both surgical approaches achieve tumor cytoreduction, the biological and immunological consequences of ablation and resection fundamentally differ.[14] These medical considerations supersede patient preference in the surgical evaluative process.

Our findings that LITT is associated with lower postoperative pain and reduced need for narcotic use compared to craniotomy bear relevance to postoperative recovery[15] as well as the recent narcotic crisis.[16] Of note, patients who underwent same-day surgical procedures show increased use of opioids, particularly after orthopedic and neurosurgical procedures.[16] Admittedly, the association between postoperative narcotic use and the opioid epidemic is not straightforward.[17] However, there is evidence suggesting that receipt of narcotic prescription in the postoperative setting increased the risk for chronic narcotic use. For instance, Alam et al. reported that individuals prescribed narcotics after low-risk surgical procedures, including laparoscopic cholecystectomy, cataract surgery, transurethral prostate resection, or varicose vein stripping, were 44% more likely to become chronic narcotic users within 1 year after the procedure relative to patients who did not receive these medications.[18] The reduced level of postoperative pain and lowered need for narcotics associated with LITT may mitigate such risks in addition to improving the quality of postoperative recovery.[19] Unfortunately, there have been no studies investigating the use of postoperative opioids and chronic opioid use in postcraniotomy patients.

TABLE 2. Survey test-retest reliability: percent intrarater agreement and reliability measures for binary data

Question	% Agreement	Cohen's Kappa	Fleiss Kappa
4. Did you have to take opioids after leaving the hospital after the craniotomy?	100%	1.00 (p = 0.08)	1.00 (p = 0.003)
8. Did you have to take opioids after leaving the hospital after the laser ablation?	100%	NA	NA
9. If you had a choice between laser ablation and craniotomy, what would you pick?	100%	1.00 (p = 0.08)	1.00 (p = 0.003)

TABLE 3. Characteristics of 27 patients with brain tumors

Variable	No. (%)
Sex	
Male	18 (66%)
Female	9 (33%)
Diagnosis	
Grade II	2 (7%)
Grade III/anaplastic	4 (15%)
Glioblastoma	21 (78%)
Tumor side	
Rt	8 (30%)
Lt	13 (48%)
Midline/multifocal	6 (22%)
Tumor location	
Corpus callosum	3 (11%)
Multifocal	3 (11%)
Frontal	7 (26%)
Insular	6 (22%)
Parietal	2 (7%)
Temporal	3 (11%)
Peri-atrial	2 (7%)
Rt motor strip	1 (4%)
LITT indication after craniotomy	
Staged surgery	11 (41%)
Recurrence	16 (59%)

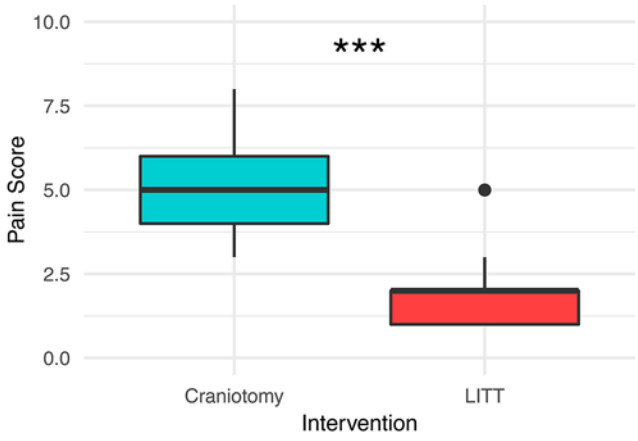

FIG. 2. Postoperative pain scores within the first 72 hours after craniotomy and LITT. ***p < 0.0001.

Given the importance of the subject, further study of this matter is warranted.

It is of interest to note that 11% of the surveyed patients preferred craniotomy relative to LITT, despite the former being associated with increased postoperative pain and narcotic use. Our qualitative review of these patients revealed that they either 1) reported better neurological outcomes postcraniotomy or 2) developed new deficits post-LITT, indicating that favorable clinical outcomes or a procedural complication superseded the quality of postoperative recovery in terms of patient preference. Given the pilot nature of our study, the sample size was inadequate for meaningful statistical analysis on this matter. Although no study to this date has explicitly examined

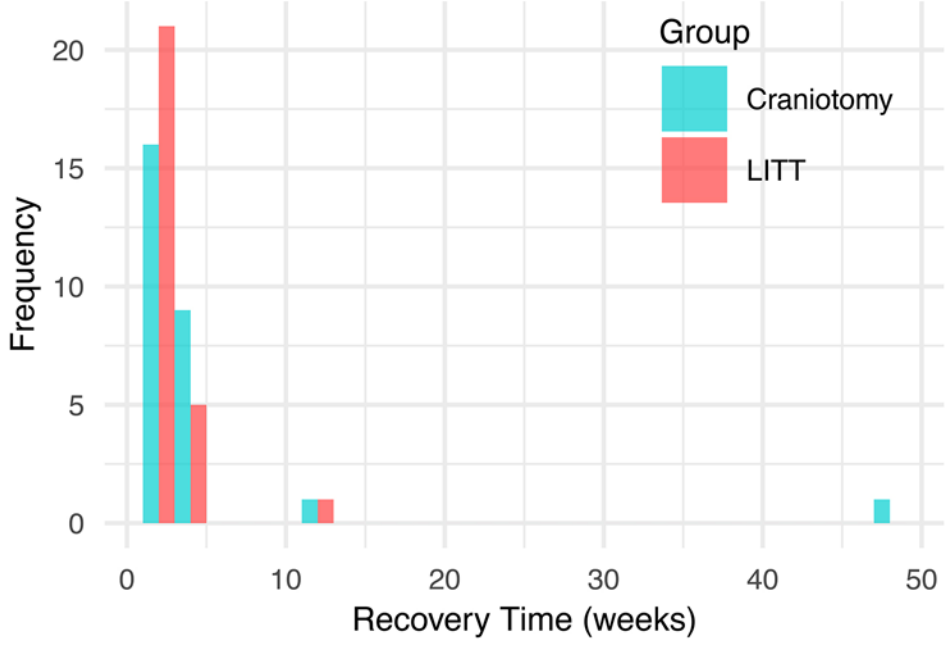

FIG. 1. Histogram of recovery time in weeks after craniotomy and LITT.

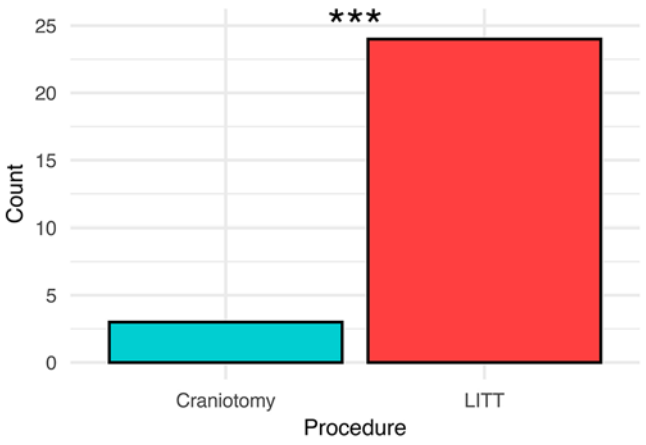

FIG. 3. Procedure preference by patients after having undergone both operations. ***p < 0.0001.

this matter, the conclusion seems intuitive and has been acknowledged by previous studies.[7,9]

Although postoperative pain is likely to have contributed to the preference of LITT over craniotomy, other explanations warrant consideration. For instance, most patients had craniotomy as their index procedure and LITT as their second procedure. As such, the reported preference may be influenced by recall bias. Additionally, the patients may have a different experience at the second neurosurgical procedure in ways that are unrelated to pain. For instance, the patient may be more familiar with the clinical team or be less anxious about the procedure. The patient may also have changed their expectations or pain tolerance. Further studies are warranted to establish a causal link between procedural preference and postoperative pain.

Limitations

Several limitations influence the interpretation of our results. First, the pilot nature of the study with a newly developed survey and the small sample size of 27 patients limits generalizability and statistical power. Second, our inclusion criteria may have introduced patient selection bias that influenced outcome measures. For instance, exclusion of patients with aphasia (i.e., those who cannot respond to the survey) may have impacted the study outcome. Third, the development and administration of the survey by the same research team introduces an element of bias. To minimize such bias, the authors who contributed to the survey development were not involved in the administration of the survey. Fourth, our survey instrument is abbreviated and may not fully capture all aspects of postoperative recovery. Fifth, none of the patients underwent optimization of preoperative analgesic regimens, such as scalp blocks prior to the procedure. Finally, for most of the patients in this case series, LITT and craniotomy were considered complementary procedures rather than competitive alternatives. Nevertheless, the study establishes the foundation for future studies, including the introduction and validation of a streamlined survey as well as an effect size for future power calculation. Considerations for future study design include a dedicated study for clinical scenarios in which there is equipoise for craniotomy and LITT and delineating the characteristics of the treated tumor (including tumor volume and location).

TABLE 4. Survey results in 27 patients with brain tumors

Outcome	LITT	Craniotomy
Overall change after surgery		
Better	1	8
Same	24	16
Worse	2	3
Time to recovery in wks	2 (1–12)	4.3 (1–48)
Postop pain, 0- to 10-point scale	1.7 (1–5)	5 (3–8)
Opioid use	1	22
Procedure preference	24	3

Values are given as number of patients or mean (range).

Conclusions

In this pilot study of 27 patients who underwent both craniotomy and LITT during distinct stages of their oncology journey, participants reported less pain and narcotic use post-LITT relative to craniotomy and generally preferred LITT.

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References

1. Curry DJ, Raskin J, Ali I, Wilfong AA. MR-guided laser ablation for the treatment of hypothalamic hamartomas. *Epilepsy Res*. 2018;142:131-134.
2. Tovar-Spinoza Z, Ziechmann R, Zyck S. Single and staged laser interstitial thermal therapy ablation for cortical tubers causing refractory epilepsy in pediatric patients. *Neurosurg Focus*. 2018;45(3):E9.
3. Karampelas I, Sloan AE. Laser-induced interstitial thermotherapy of gliomas. *Prog Neurol Surg*. 2018;32:14-26.
4. Jethwa PR, Barrese JC, Gowda A, Shetty A, Danish SF. Magnetic resonance thermometry-guided laser-induced thermal therapy for intracranial neoplasms: initial experience. *Neurosurgery*. 2012;71(1 Suppl Operative):133-145.
5. Do TH, Howard MA, Palzer EF, et al. Readmission risk of malignant brain tumor patients undergoing laser interstitial thermal therapy (LITT) and stereotactic needle biopsy (SNB): a covariate balancing weights analysis of the National Readmissions Database (NRD). *J Neurooncol*. 2022;159(3):553-561.
6. Sharma M, Do TH, Palzer EF, Huling JD, Chen CC. Comparable safety profile between neuro-oncology procedures involving stereotactic needle biopsy (SNB) followed by laser interstitial thermal therapy (LITT) and LITT alone procedures. *J Neurooncol*. 2023;162(1):147-156.
7. Tovar-Spinoza Z, Choi H. MRI-guided laser interstitial thermal therapy for the treatment of low-grade gliomas in children: a case-series review, description of the current technologies and perspectives. *Childs Nerv Syst*. 2016;32(10):1947-1956.
8. Traylor JI, Patel R, Muir M, et al. Laser interstitial thermal therapy for glioblastoma: a single-center experience. *World Neurosurg*. 2021;149:e244-e252.

9. Kim AH, Tatter S, Rao G, et al. Laser Ablation of Abnormal Neurological Tissue Using Robotic NeuroBlate System (LAANTERN): 12-month outcomes and quality of life after brain tumor ablation. *Neurosurgery*. 2020;87(3):E338-E346.
10. Weir JP. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *J Strength Cond Res*. 2005;19(1):231-240.
11. Young JS, Morshed RA, Hervey-Jumper SL, Berger MS. The surgical management of diffuse gliomas: current state of neurosurgical management and future directions. *Neuro Oncol*. 2023;25(12):2117-2133.
12. Patel P, Patel NV, Danish SF. Intracranial MR-guided laser-induced thermal therapy: single-center experience with the Visualase thermal therapy system. *J Neurosurg*. 2016;125(4):853-860.
13. Kuhnt D, Becker A, Ganslandt O, Bauer M, Buchfelder M, Nimsky C. Correlation of the extent of tumor volume resection and patient survival in surgery of glioblastoma multiforme with high-field intraoperative MRI guidance. *Neuro Oncol*. 2011;13(12):1339-1348.
14. Leuthardt EC, Duan C, Kim MJ, et al. Hyperthermic laser ablation of recurrent glioblastoma leads to temporary disruption of the peritumoral blood brain barrier. *PLoS One*. 2016;11(2):e0148613.
15. Betchen SA, Walsh J, Post KD. Self-assessed quality of life after acoustic neuroma surgery. *J Neurosurg*. 2003;99(5):818-823.
16. Wilson JL, Poulin PA, Sikorski R, Nathan HJ, Taljaard M, Smyth C. Opioid use among same-day surgery patients: prevalence, management and outcomes. *Pain Res Manag*. 2015;20(6):300-304.
17. McDonald DC, Carlson K, Izrael D. Geographic variation in opioid prescribing in the U.S. *J Pain*. 2012;13(10):988-996.
18. Alam A, Gomes T, Zheng H, Mamdani MM, Juurlink DN, Bell CM. Long-term analgesic use after low-risk surgery: a retrospective cohort study. *Arch Intern Med*. 2012;172(5):425-430.
19. Gan TJ. Poorly controlled postoperative pain: prevalence, consequences, and prevention. *J Pain Res*. 2017;10:2287-2298.

Disclosures

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Author Contributions

Conception and design: Chen. Acquisition of data: Chen, Ben-Haim. Analysis and interpretation of data: Chen, Peña Pino, Bartek. Drafting the article: Chen, Peña Pino. Critically revising the article: Chen, Peña Pino, Bartek. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Chen. Statistical analysis: Chen, Peña Pino. Administrative/technical/material support: Chen. Study supervision: Chen.

Supplemental Information

Online-Only Content

Supplemental material is available online.

Supplemental Survey and Table. https://thejns.org/doi/suppl/10.3171/2024.8.FOCUS24442.

Correspondence

Clark C. Chen: Brown University, Providence, RI. clark_chen@brown.edu.