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Case Report

Laser ablation of a sphenoid wing meningioma: A case report and review of the literature

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ABSTRACT

Background: Meningiomas are the most common primary central nervous system neoplasm in the United States. While the majority of meningiomas are benign, the World Health Organization (WHO) Grade I tumors, a not-insignificant proportion of tumors are in anatomically complex locations or demonstrate more aggressive phenotypes, presenting a challenge for local disease control with surgery and radiation. Laser interstitial thermal therapy (LITT) consists of stereotactic delivery of laser light for tumor ablation and is minimally invasive, requiring implantation of a laser fiber through a cranial burr hole. Herein, we demonstrate the first use of this technology in a progressive atypical sphenoid wing meningioma for a previously resected and irradiated tumor.

Case Description: A 47-year-old female was diagnosed with a left-sided atypical meningioma, the WHO 2, of the sphenoid wing following acute worsening of bitemporal headache and dizziness. Given neurovascular involvement, a subtotal resection was performed, followed by stereotactic radiosurgery. Following progression 9 months from resection, the patient elected to proceed with LITT. The patient's postoperative course was uncomplicated and she remains progression free at 24 months following LITT.

Conclusion: We present the first use of LITT for a sphenoid wing meningioma documented in the literature, which demonstrated enhanced disease control for a lesion that was refractory to both surgery and radiation. LITT could represent an additional option for local control of progressive meningiomas, even in locations that are challenging to access surgically. More evidence is needed regarding the technical nuances of LITT for lesions of the skull base.

Keywords: Brain tumors, Case report, Laser ablation, Laser interstitial thermal therapy, Skull base, Sphenoid wing meningioma

INTRODUCTION

Meningiomas are the most common primary neoplasm of the central nervous system (CNS) in the United States.[14] Increased incidence is seen with aging, Black or African American descent, or female sex.[3,14] The vast majority of meningiomas are benign lesions with an indolent course.[14] Such tumors are typically classed as Grade 1 in the World Health Organization (WHO) classification of tumors of the CNS. However, 28–33% of meningiomas demonstrate higher-grade phenotypes, with invasion of the adjacent parenchyma and malignant-appearing histopathology.[11] Such WHO 2 (atypical) and WHO 3 (malignant) meningiomas are associated with 10-year overall survival of 67.5%, with increased age portending a worse prognosis.[14] Standard of care for patients with symptomatic or rapidly growing meningiomas is maximal neurosurgical resection to prevent recurrence.[19] While subsequent therapy with stereotactic radiosurgery (SRS) is an option to enhance local disease control, patients with higher-grade tumors frequently progress despite surgery and radiotherapy with a 6-month progression-free survival of only 26% for this population.[2] Such tumors present a challenge for reoperation given frequent destruction of the bone and radiation-induced scarring.[2,3]

In patients with recurrent high-grade meningioma, laser interstitial thermal therapy (LITT) may represent a minimally invasive alternative to open resection for eliciting surgical cytoreduction. Briefly, in the case of the NeuroBlate® system, a laser fiber is stereotactically placed within a target lesion using a standard burr hole, and 1064 nm Nd: YAG laser light is used to produce coagulative necrosis under real-time monitoring with magnetic resonance (MR) thermography. This mechanism has been adopted for ablation or cytoreduction in a variety of intracranial pathologies, including epileptic foci and movement disorders as well as both primary and recurrent gliomas and brain metastases. As the procedure is minimally-invasive, it may significantly reduce operative morbidity in previously-resected or irradiated recurrent disease.[8,17] The use of LITT for meningiomas has thus far been infrequently studied, with published case series focusing on treatment of parasagittal or parafalcine tumors.[6,16,20] Skull-base meningiomas have distinct pathologic phenotypes; gross total resection (GTR) of these lesions may be performed by experienced neurosurgeons, but is limited by the need to protect the vital structures of this anatomic region.[2,3] This can become even more challenging in the case of tumor recurrence, where the therapeutic window for resection becomes significantly narrowed. A minimally invasive procedure can alter the risk profile for such a procedure and re-broaden the window. This report is the first account demonstrating the safety and feasibility of LITT for a recurrent atypical sphenoid wing meningioma.

CASE DESCRIPTION

Patient presentation

A 47-year-old woman presented to urgent care with acute worsening of bitemporal headache and dizziness over the course of 2 weeks. She was noted to have had subjective personality changes in the previous several months, but otherwise her neurological examination was non-focal. Referral to an outside emergency department revealed a large left mass arising from the sphenoid wing measuring 5.2 × 4.2 × 6.1 cm with significant vasogenic edema on the frontotemporal regions, 1 cm of midline shift, and enhancing nodular and cystic components on MR imaging (MRI), with displacement of the middle cerebral artery (MCA) M1 and M2 segments and invasion of the calvarium. Initial imaging is shown in Figure 1a. The imaging favored atypical meningioma however glioma and malignant skull-base tumor were on the differential diagnosis. Given the skull-base location and extent of tumor, the patient was referred to our institution for definitive resection. The patient consented to participate in this report, which was written according to surgical case report guidelines and did not require review by the health system Institutional Review Board.[1]

Initial surgery

The patient had a preoperative cerebral angiogram with particle embolization of feeding vessels from the left middle meningeal artery. She then underwent a left frontotemporal craniotomy with osteotomy of the greater wing of the sphenoid. A subtotal Simpson grade IV resection was performed, limited by tumor encapsulation of the third nerve and involvement of the striate vessels of the inferior frontal lobe. Postoperatively, the patient had a new left upper eyelid ptosis and facial numbness at the craniotomy site, but was otherwise without complications. She was discharged home on postoperative day (POD) 2 without incident.

Pathology

Histopathological assessment revealed a spindle-cell neoplasm with whorling and collagen deposition. There was nuclear atypia and increased mitotic figures with some areas of necrosis, but no invasion of brain tissue. The KI-67 index was 10% and the lesion was epithelial membrane antigen positive and signal transducer and activator of transcription 6 negative. The final WHO integrated diagnosis was atypical meningioma, the WHO Grade 2.

Postoperative course

The patient developed significant left-sided headaches in the area of her craniotomy for which she began taking butalbital/acetaminophen. Six-week postoperative MRI revealed 2.3 × 2.7 cm of residual enhancing tumor along the left sphenoid wing as expected [Figure 1b]. It was recommended that the patient undergo radiation therapy. She was treated with intensity-modulated radiation therapy up to 57.6 Gy in 1.8 Gy fractions without new complications. Unfortunately, postradiation MRI [9 months total postoperative, Figure 1c] showed increased tumor size to 3 cm in maximal diameter and contrast enhancement along the sphenoid wing with possible bone infiltration. There was also new T2 signal abnormality in the white matter of the left frontal lobe. The patient was offered continued observation, repeat resection,

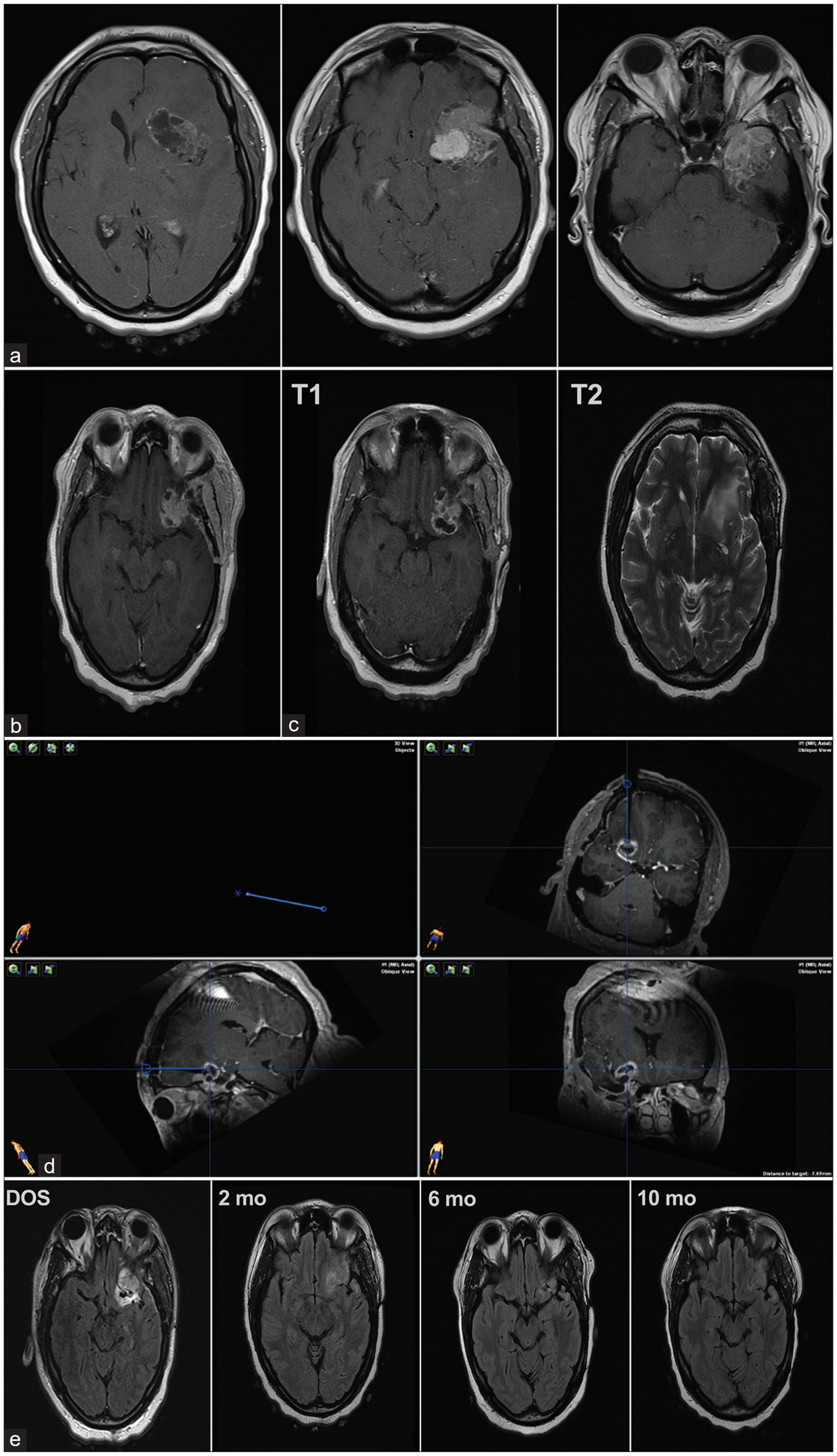

Figure 1: Representative magnetic resonance imaging of the tumor at varying time points. (a) Contrasted T1 images before resection (b) Contrasted T1 image post-resection, pre- intensity-modulated radiation therapy (c) T1 (left) and T2 (right) images post-stereotactic radiosurgery, pre-laser interstitial thermal therapy (LITT). (d) The chosen supraorbital biopsy/LITT tract terminating anterior to the middle cerebral artery is shown (clockwise from top right) in axial, coronal, and sagittal views in neuronavigation software. (e) Post-LITT fluid attenuated inversion recovery imaging intraoperatively (day of surgery, DOS) and at 2 months (2 mo), 6 months (6 mo), and 10 months (10 mo), respectively.

or LITT for the lesion and ultimately elected for LITT 10 months from her initial surgery.

LITT and post-LITT course

The patient was placed in the supine position. A supraorbital approach along the long axis of tumor was chosen for biopsy and laser ablation. The target location of the fiber tip was planned for the base of the frontal lobe in front of the MCA. Biopsy to rule out radiation necrosis or development of higher-grade features again demonstrated atypical meningioma, the WHO Grade 2. Following biopsy, the patient was transitioned into the intraoperative MRI and the lesion was ablated from deep to superficial with multiple rounds of lasing in 360° under real-time MR thermography monitoring. Special caution was taken to create a trajectory sparing the cranial nerves and other eloquent structures, as shown in neuronavigation software [Figure 1d]. No complications or new deficits were noted, and the patient was discharged on post-operative day 1 (POD 1) with prophylactic levetiracetam and a dexamethasone taper. At her 2-week postoperative visit, she reported an increase in her left-sided frontal headaches and was restarted on dexamethasone with transition to her butalbital/acetaminophen regimen. The patient ultimately pursued disability due to persistent blurry vision and short-term memory deficits following her prior surgery. Follow-up MRIs have been stable, and the patient has remained progression free at 24 months post-LITT [Figure 1e].

DISCUSSION

This case represents the first use of LITT in a patient with a progressive atypical sphenoid wing meningioma. Given the limited availability of high-quality evidence for imaging follow-up and reoperation for recurrent disease, management of recurrent meningiomas is complex.[19] Simpson's seminal work established the importance of upfront maximal surgical resection for meningiomas, while modern trends have focused on balancing the need for resection with risk of morbidity, the importance of surgery for these tumors remains evident.[2,19] For residual or high-grade tumors, as well as recurrent disease, multiple studies have suggested the importance of fractionated radiotherapy for enhanced local control.[12] Repeat surgery for recurrent tumors represents a technical challenge due to scarring and impaired wound healing. In the case of skull-base tumors, the risk of morbidity is heightened due to frequent invasion of vasculature or cranial nerves. In this setting, LITT may provide the benefit of tumor cytoreduction while avoiding the risks of an open surgery.

Thus far, LITT has been infrequently used in meningiomas. As 80% of meningiomas are benign, the WHO Grade 1 tumors that may be asymptomatic and simply followed on imaging, while convexity or parafalcine/parasagittal lesions are often definitively treated with open surgery alone, the majority of patients will not have progression such that LITT is indicated.[19] Furthermore, in addition to posing a significant operative challenge, skull-base meningiomas are thought to have a unique natural history relative to other disease locations; as a result, there is need for increased research on viable treatment options for these tumors.[2,3] A more detailed understanding of the molecular differences between meningioma subtypes may help identify which patients will derive benefit from specific therapies, including LITT.[13] LITT has seen widespread adoption in the neurosurgical community for the treatment of epileptic foci, movement disorders, and a variety of brain tumors, including gliomas and brain metastases.[8,17] Biopsy and LITT can be performed through the same trajectory during a single case, making the paradigm extremely useful for identification of radiation necrosis versus recurrent disease in previously-irradiated tumors.[21] In other tumor types, LITT has been shown to be comparable to open resection in terms of care utilization and costs.[8] It should be noted that tumors are typically selected for LITT based in part on diameter <3 cm, due to risk of symptomatic post-LITT edema.[15,22] Risks of LITT are otherwise similar to those of open craniotomy.[4] However, given the prolonged recovery and morbidity that are possible with open surgery in the skull base and frequent long-term survival of meningioma patients, the use of LITT may further decrease costs and improve outcomes outside of the immediate surgical period.

In our review of the literature, we were unable to identify any articles discussing the use of LITT in skull-base meningiomas. In 2018, meningiomas made up only 4% of the LAANTERN database, which includes data on patients treated with LITT through the NeuroBlate system.[17] We identified three other series discussing outcomes of LITT in meningiomas, two of which consisted of the same set of patients [Table 1].[6,16,20] All articles only discussed treatment of parafalcine or parasagittal lesions. Interestingly, one recent large series discussing resection for parafalcine/parasagittal lesions endorsed that with the advent of SRS and LITT for management of this disease, traditional GTR might be less necessary and result in decreased patient morbidity.[5] This may also be advantageous for skull-base meningiomas, and particularly recurrent tumors, given GTR is not always possible in these instances. We additionally identified two articles by Kato *et al.*, published before the maturation of MR thermography, that provided evidence for the utility of radiofrequency ablation (RFA) in local control of two sphenoid ridge and one anterior skull-base meningioma.[9,10,18] Interestingly, they noted maximal temperatures of ~80°C and lack of increased tissue impedance typically used to monitor RFA completion and avoid boiling or charring. Ablation in the skull base likely has unique challenges

Table 1: Review of published articles on LITT for meningiomas; when applicable, data are reported as medians with ranges.

Citation	*n*	Age	Sex	KPS	Pathology	Location	Prior Surgery	Prior Radiation	PFS (weeks)	EOA (%)
Ivan *et al*., 2017[6]	4	67 (65–82)	F: 2 M: 2	95 (90–100)	Grade 1: 3 Grade 3: 1	Parafalcine: 1 Parasagittal: 3	4	4	38.45 (8.3–89.9)	82.5 (61–97)
Ruiz *et al*., 2018[20]*	-	-	-	-	-	-	-	-	-	-
Rammo *et al*., 2019[16]	3	67 (58–79)	F: 2 M: 1		Grade 3: 2 Indeterminate: 1	Parasagittal: 3	3	2	11.4 (5.7–121.7)	53.5% (49–62)

*Ruiz *et al*. includes the same set of patients as the earlier study by Ivan *et al*. F: female, M: male, LITT: Laser interstitial thermal therapy, KPS: Karnofsky Performance Score, PFS: Progression-free survival, EOA: Extent of ablation

relative to other areas of the brain, and systematic guidance for navigation of intracranial heat sinks would be beneficial for future surgical planning.[7]

CONCLUSION

In our patient's case, LITT appeared to halt further progression despite the worrisome lack of response to SRS. The procedure was performed safely and without complication, with stable follow-up imaging out to 10 months. As the first known example of LITT for progressive atypical skull-base meningioma, this report demonstrates feasibility and potential benefit of the application. In the future, LITT could be employed more frequently in appropriately selected meningiomas of the skull base when delicate vasculature and cranial nerves can be avoided. As the applications of LITT continue to increase in neurosurgical oncology, discussion of novel use cases provides significant value in guiding evolution of the technology.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

Dr. Peter E. Fecci is a consultant for Monteris Medical.

REFERENCES

1. Agha RA, Franchi T, Sohrabi C, Mathew G, Kerwan A, SCARE Group. The SCARE 2020 guideline: Updating consensus surgical case report (SCARE) guidelines. Int J Surg 2020;84:226-30.
2. Brastianos PK, Galanis E, Butowski N, Chan JW, Dunn IF, Goldbrunner R, *et al*. Advances in multidisciplinary therapy for meningiomas. Neuro Oncol 2019;21 Suppl 1:i18-31.
3. Buerki RA, Horbinski CM, Kruser T, Horowitz PM, James CD, Lukas RV. An overview of meningiomas. Future Oncol 2018;14:2161-77.
4. de Groot JF, Kim AH, Prabhu S, Rao G, Laxton AW, Fecci PE, *et al*. Efficacy of laser interstitial thermal therapy (LITT) for newly diagnosed and recurrent IDH wild-type glioblastoma. Neurooncol Adv 2022;4:vdac040.
5. Eichberg DG, Casabella AM, Menaker SA, Shah AH, Komotar RJ. Parasagittal and parafalcine meningiomas: Integral strategy for optimizing safety and retrospective review of a single surgeon series. Br J Neurosurg 2020;34:559-64.
6. Ivan ME, Diaz RJ, Berger MH, Basil GW, Osiason DA, Plate T, *et al*. Magnetic resonance-guided laser ablation for the treatment of recurrent dural-based lesions: A series of five cases. World Neurosurg 2017;98:162-70.
7. Jermakowicz WJ, Cajigas I, Dan L, Guerra S, Sur S, D'Haese PF, *et al*. Ablation dynamics during laser interstitial thermal therapy for mesiotemporal epilepsy. PLoS One 2018;13:e0199190.
8. Johnson RA, Do TH, Palzer EF, Cramer SW, Hanson JT, Huling JD, *et al*. Pattern of technology diffusion in the adoption of stereotactic laser interstitial thermal therapy (LITT) in neuro-oncology. J Neurooncol 2021;153:417-24.
9. Kato A, Fujimoto Y, Hashimoto N, Taniguchi M, Kinoshita M, Hirayama A, *et al*. Radiofrequency thermal ablation for recurrent meningioma extending extracranially. Acta Neurochir (Wien) 2005;147:543-50; discussion 550.
10. Kato A, Fujimoto Y, Taniguchi M, Hashimoto N, Hirayama A, Kinoshita M, *et al*. Volumetric thermal devascularization of large meningiomas. J Neurosurg 2004;101:779-86.
11. Louis DN, Perry A, Wesseling P, Brat DJ, Cree IA, Figarella-Branger D, *et al*. The 2021 WHO classification of tumors of the central nervous system: A summary. Neuro Oncol 2021;23:1231-51.
12. Magill ST, Lee DS, Yen AJ, Lucas CH, Raleigh DR, Aghi MK, *et al*. Surgical outcomes after reoperation for recurrent skull base meningiomas. J Neurosurg 2019;130:876-83.
13. Nassiri F, Liu J, Patil V, Mamatjan Y, Wang JZ, Hugh-White R, *et al*. A clinically applicable integrative molecular classification of meningiomas. Nature 2021;597:119-25.
14. Ostrom QT, Cioffi G, Waite K, Kruchko C, Barnholtz-Sloan JS. CBTRUS statistical report: Primary brain and other central nervous system tumors diagnosed in the United States in 2014-2018. Neuro Oncol 2021;23 Suppl 3:iii1-105.
15. Pisipati S, Smith KA, Shah K, Ebersole K, Chamoun RB, Camarata PJ. Intracerebral laser interstitial thermal therapy

followed by tumor resection to minimize cerebral edema. Neurosurg Focus 2016;41:E13.
16. Rammo R, Scarpace L, Nagaraja T, Lee I. MR-guided laser interstitial thermal therapy in the treatment of recurrent intracranial meningiomas. Lasers Surg Med 2019;51:245-50.
17. Rennert RC, Khan U, Tatter SB, Field M, Toyota B, Fecci PE, *et al*. Patterns of clinical use of stereotactic laser ablation: Analysis of a multicenter prospective registry. World Neurosurg 2018;116:e566-70.
18. Rieke V, Pauly KB. MR thermometry. J Magn Reson Imaging 2008;27:376-90.
19. Rogers L, Barani I, Chamberlain M, Kaley TJ, McDermott M, Raizer J, *et al*. Meningiomas: Knowledge base, treatment outcomes, and uncertainties. A RANO review. J Neurosurg 2015;122:4-23.
20. Ruiz A, Diaz RJ, Buttrick S, Ivan M, Desai M, Komotar RJ, *et al*. Preliminary experience on laser interstitial thermal ablation therapy in the treatment of extra-axial masses: Indications, imaging characterization and outcomes. Cureus 2018;10:e2894-94.
21. Srinivasan ES, Grabowski MM, Nahed BV, Barnett GH, Fecci PE. Laser interstitial thermal therapy for brain metastases. Neuro Oncol Adv 2021;3 Suppl 5:v16-25.
22. Wright J, Chugh J, Wright CH, Alonso F, Hdeib A, Gittleman H, *et al*. Laser interstitial thermal therapy followed by minimal-access transsulcal resection for the treatment of large and difficult to access brain tumors. Neurosurg Focus 2016;41:E14.

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