Laser-Interstitial Thermal Therapy for Refractory Cerebral Edema from Post-Radiosurgery Metastasis

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Key words
- Edema
- Laser
- Metastasis
- Necrosis
- Radiation
- Thermal

Abbreviations and Acronyms
LITT: Laser-interstitial thermal therapy
MR: Magnetic resonance

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BACKGROUND: **Stereotactic radiosurgery is often an effective tool for the treatment of brain metastases. A complication of radiosurgical treatment for brain metastasis can be persistent cerebral edema. Treatments of this refractory cerebral edema include observation, corticosteroids, and surgical resection of the edema-inducing mass. Laser-interstitial thermal therapy is a minimally invasive technique for ablating intracranial lesions. It may provide a treatment option for metastases after radiosurgery causing refractory cerebral edema.**

CASE DESCRIPTION: **We report the case of a 64-year-old man with lung adenocarcinoma presenting to our department with left hemiparesis. Brain magnetic resonance imaging showed an 18-mm enhancing lesion in the right external capsule with significant surrounding edema. The lesion was treated by radiosurgery. There was persistent edema after radiosurgery. The patient required continued corticosteroid therapy to maintain his ability to ambulate. He developed refractory hyperglycemia, weight gain, and bilateral proximal muscle weakness secondary to this therapy. Fourteen weeks after radiosurgery, he underwent laser-interstitial thermal therapy for lesion ablation. He was weaned off corticosteroids during 2 weeks and maintained his strength during the following month.**

CONCLUSIONS: **Laser-interstitial thermal therapy may be a treatment option for refractory cerebral edema after stereotactic radiosurgery to a metastasis. This therapy may be of particular use in deep-seated lesions refractory to corticosteroid therapy.**

INTRODUCTION

Stereotactic radiosurgery is often the treatment of choice for brain metastases (5). Persistent or worsening cerebral edema can occur after radiosurgery and, in some instances, patients can develop radiation necrosis (1). Treatment of this edema includes observation, corticosteroid therapy, and surgical removal of the mass. Systemic side effects from corticosteroids and lesions that are difficult to access surgically can make the treatment of edema after radiosurgery for a metastasis difficult.

Laser-interstitial thermal therapy (LITT) delivers focal heat energy to coagulate tissue with a sharp ablation boundary zone (8). Intracranial LITT involves the stereotactic placement of a probe into a lesion followed by laser ablation while performing real-time magnetic resonance (MR) thermometry to monitor intracranial temperature. Recent studies have suggested the utility of LITT in the treatment of brain metastases and intracranial radiation necrosis (2, 8).

Persistent cerebral edema despite conventional therapies in patients with brain metastases remains a neurosurgical challenge. Current alternative therapies include bevacizumab and pentoxifylline combined with vitamin E (6, 10). LITT may be a useful treatment option for cerebral edema after stereotactic radiosurgery to a metastasis.

CASE REPORT

History and Physical Examination

A 64-year-old man with lung adenocarcinoma presented with left hemiparesis. He was diagnosed with stage IIIB lung adenocarcinoma 3 years prior, for which he underwent a pneumonectomy followed by chest radiotherapy and cisplatin–gemcitabine chemotherapy. The patient's past medical history was significant for hypertension, atrial fibrillation, and coronary artery disease status after coronary artery bypass grafting. On physical examination, the patient had a left hemiparesis with left proximal lower extremity strength of 2/5 and was unable to ambulate. His right lower extremity was full strength. Of note, he had no history of diabetes mellitus and his admission blood glucose level was 118 mg/dL.

Imaging Findings and Preoperative Course

MR imaging of the brain showed an 18-mm contrast-enhancing lesion in the right hemisphere adjacent to the external capsule just anterior to descending motor fibers with significant surrounding edema consistent with a brain metastasis (**Figure 1A**). The patient was started on corticosteroid therapy (dexamethasone), and his strength improved to a level where he was able to ambulate with a walker. His

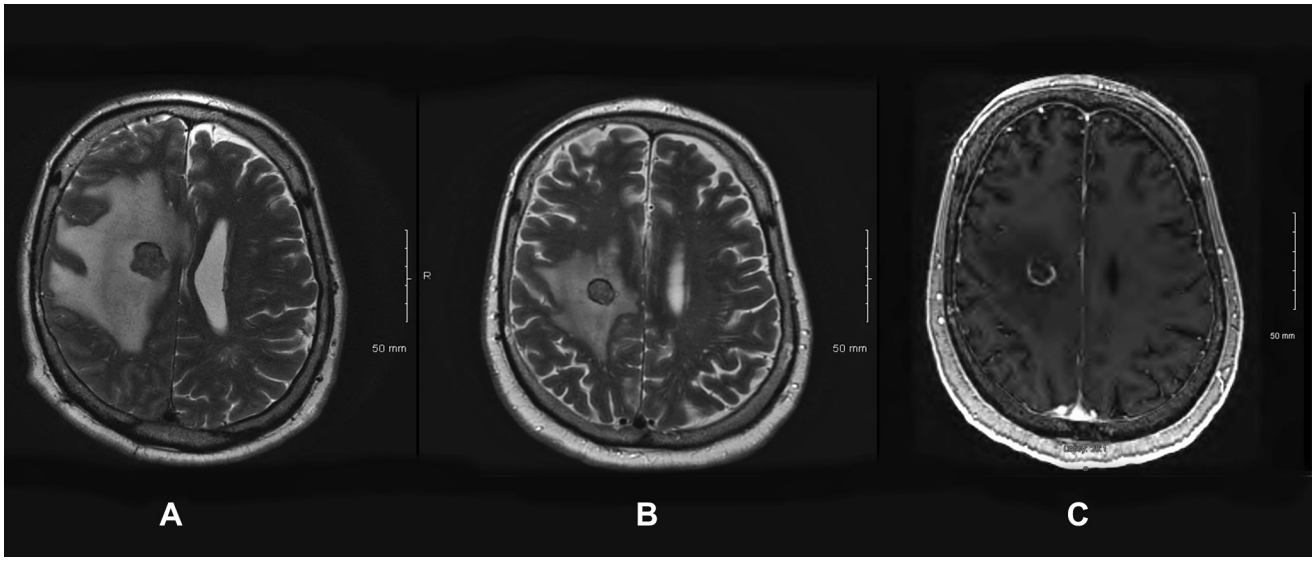

Figure 1. Representative T_2-weighted axial magnetic resonance images demonstrating cerebral edema in a 64-year-old man with a lung adenocarcinoma brain metastasis. (**A**) At presentation. (**B**) Fourteen weeks after stereotactic radiosurgery while the patient was receiving high-dose corticosteroid therapy. (**C**) Gadolinium-enhanced T_1-weighted image at 14 weeks after stereotactic radiosurgery showing partial marginal enhancement.

proximal left lower extremity strengthened while receiving corticosteroid therapy, which was 4-/5.

Operations and Hospital Course

The lesion was treated by gamma knife (Elekta, Stockholm, Sweden) stereotactic radiosurgery with a dose of 16 Gy to the tumor margin. There was persistent edema after radiosurgery (Figure 1B), and the patient required continued corticosteroid therapy to maintain his ability to ambulate with assistance. Gadolinium-enhanced MR imaging (Figure 1C) revealed a T_1/T_2 mismatch (7). The patient developed refractory hyperglycemia requiring insulin injection, weight gain, and bilateral proximal muscle weakness (3/5 left, 4/5 right) secondary to the corticosteroids. He was considered a poor candidate for a craniotomy given the deep location of the edema-inducing lesion and his medical comorbidities.

Fourteen weeks after radiosurgery, the patient underwent LITT ablation of the lesion under general anesthesia. A frameless stereotactic navigation system (Medtronic, Minneapolis, Minnesota, USA) was used to place a Visualase probe (Visualase Inc., Houston, Texas, USA) into the lesion through a 2-cm incision using a method similar to the placement of a stereotactic brain biopsy needle. The patient was then transported to the MR imaging suite. An initial image was obtained to confirm adequate placement of the probe (Figure 2). Real-time gradient echo MR thermometry was then used to constantly monitor the intracranial temperature. Several automatic stops were set in the brain surrounding the lesion to limit any damage to the surrounding tissue. Although continuous irrigation was maintained through the probe to control the temperature of the 980-nm diode laser, a thermal ablation of the lesion was performed. The lesion was treated at a temperature of 60° to 95°C, and the treatment time was 2 minutes. An MR image after the ablation was obtained to verify that the treated area matched the surgical goal and there was no evidence of intracranial hemorrhage. The probe was removed, and the incision was closed in the recovery room. The patient went home on the first postoperative day, without issue.

Postoperative Course

The patient was weaned off of corticosteroid therapy during the next 2 weeks. MR imaging at that time showed decreased edema (Figure 3A). At 10 weeks after the procedure, he was not receiving corticosteroids and was ambulating without assistance. MR imaging showed a decrease in the size of the lesion and a small amount of residual edema (Figure 3B). The patient's right proximal lower extremity returned to full strength, and his left proximal lower extremity strength was 4+/5.

DISCUSSION

Multiple treatment options exist after stereotactic radiosurgery radiation necrosis. In patients who are asymptomatic, close monitoring with serial imaging is often

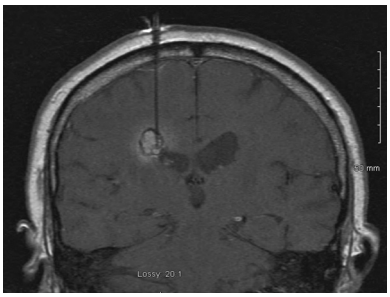

Figure 2. Representative T_1-weighted coronal magnetic resonance image demonstrating a laser-interstitial thermal therapy probe placed within a lesion just before thermal ablation.

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