MRI and CT Guided Cryoablation for Intracranial Extension of Malignancies along the Trigeminal Nerve

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Abstract

Objectives To describe the technical aspects and early clinical outcomes of patients undergoing percutaneous magnetic resonance imaging (MRI)-guided tumor cryoablation along the intracranial trigeminal nerve.

Design This study is a retrospective case review.

Setting Large academic tertiary care hospital.

Participants Patients who underwent MRI-guided cryoablation of perineural tumor along the intracranial trigeminal nerve.

Main Outcome Measures Technical success, pain relief, local control.

Results Percutaneous MRI-guided cryoablation of tumor spread along the intracranial portion of the trigeminal nerve was performed in two patients without complication, with subsequent pain relief, and with local control in the patient with follow-up imaging.

Conclusions Percutaneous MRI-guided cryoablation is a feasible treatment option for malignancies tracking intracranially along the trigeminal nerve.

Keywords

- ▶ skull base
- ▶ trigeminal nerve
- ▶ foramen ovale
- ▶ cryoablation

Introduction

Perineural spread of tumors at the skull base that involve the brain can be difficult to manage and may benefit from multidisciplinary, multimodality treatment that includes percutaneous magnetic resonance imaging (MRI)-guided cryoablation.

Trigeminal neuralgia is frequently treated with trigeminal nerve ablation. Electrocoagulation was first described in 1913 while radiofrequency ablation of the preganglionic trigeminal rootlets was introduced in 1974.¹ Such procedures are typically performed today with fluoroscopy guidance of a needle to the foramen ovale and Meckel's cave. Unfortunately, for patients with tumor, tumor is not visible

with fluoroscopy and tumor proximal to the zone of ablation will not be treated.

Over the last 20 years, image-guided thermal ablation techniques have emerged for treatment of tumors throughout the body.² The risk of permanent neural injury has been a concern when ablating tumors involving the central nervous system,³ due to the inability to accurately monitor the zone of ablation when using fluoroscopy or CT guidance, particularly with heat-based techniques. MRI-guidance provides anatomic central nervous system (CNS) soft tissue and tumor detail and distinctly shows the region of cryoablation.⁴ Several recent reports have documented successful MRI-guided cryoablation of tumors adjacent to major neurovascular structures in the face and spine.^{5–7}

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In this report, we show that MRI-guided cryoablation may be a safe, minimally invasive, and feasible option in the multimodality treatment of perineural tumor spread into the skull base and cranial vault.

Technique and Results

We present the procedure details and medical imaging of two patients with perineural tumor spread along the trigeminal nerve in the intracranial aspect of the skull base. This study was approved by our institutional review board.

For both patients, a multidisciplinary tumor board determined that surgery was not indicated. Both procedures were performed in the MRI procedure room of a multimodality image-guided operating suite with a 3T Magnetom Verio MRI system (Siemens, Malvern, PA, United States). Cryoablation was performed using IceSeed cryoprobes with the SeedNet cryoablation system (Galil Medical, Minneapolis, MN, United States). An anesthesiologist administered general endotracheal anesthesia. No perioperative antibiotics were administered.

Patient one was a 67-year-old female with a history of right parotid gland adenoid cystic carcinoma, initially resected 14 years prior. After discontinuation of thalidomide due to suspected cardiac toxicity, she developed a right V3

trigeminal nerve branch metastasis that caused severe stabbing facial pain. As previously reported, this lesion was successfully cryoablated with resolution of pain.⁶ One year later; the metastasis recurred deep to the prior ablation, extending into the inferior temporal lobe. Repeat cryoablation was performed. One IceSeed probe (length, 175 mm; diameter, 1.5 mm, Galil Medical Inc, Arden Hills, MN, United States) was placed from a submandibular approach through the right foramen ovale with the tip of the probe positioned in the inferomedial right temporal lobe (►Fig. 1). Cryoablation was monitored with rapid coronal T2-weighted MRI (TR 3000 ms, TSE 100 ms, and 1 minute duration per scan) and performed as follows: 15 minute freeze at 20% power, 10 minute active thaw, and 15 minute freeze at 20%. The procedure was technically successful without perioperative complication. The patient was discharged home with a normal neurological exam four hours postprocedure with a one week prescription of levetiracetam for seizure prophylaxis. Follow-up imaging 3 months postprocedure demonstrated tumor resolution (►Fig. 1C). One year later, recurrence was found posterolateral to the foramen ovale. Repeat cryoablation with the probe through foramen ovale was limited by the proximity of the third, fourth, and sixth cranial nerves and did not result in regression on six month

Fig. 1 A 67-year-old female with history of right parotid adenoid cystic carcinoma 14 years ago with metastasis along the right trigeminal nerve previously cryoablated with resolution of severe facial pain, now with epidural recurrence extending to the inferior right temporal lobe. (A) Coronal T1-weighted postcontrast image shows nodular epidural enhancement (arrow) at the right foramen ovale extending to the inferior right temporal lobe. (B) Coronal T2-weighted intraoperative image shows cryoprobe via a submandibular approach with tip in the inferior right temporal lobe and ice ball centered on the epidural disease. (C) Coronal T1-weighted postcontrast image 3 months post-ablation shows resolution of nodular epidural disease. (D) Frontal, and (E) lateral 3D CT reformats, and (F) obliquely reformatted CT image in bone windows demonstrate the trajectory of the needle (arrows) from the submandibular region to the skull base. 3D, Three dimensional; CT, computed tomography.

Fig. 2 A 67-year-old female with history of right parotid adenoid cystic carcinoma 14 years ago with metastasis along the right trigeminal nerve previously cryoablated with resolution of severe facial pain, now with epidural recurrence extending to the inferior right temporal lobe. Coronal CT image shows cryoablation probe through an 11G power driver needle (black arrow) through the skull base posterolateral to the widened foramen ovale (white arrow). CT, computed tomography.

follow-up imaging, so another cryoablation (10 minute freeze at 40%, 10 minute active thaw, and 10 minute freeze at 40%) was performed after drilling with an Arrow OnControl power drill with 11/13G coaxial biopsy set (Teleflex Inc., Wayne PA, United States) through the skull base posterolateral to the foramen ovale to center the probe on the recurrent epidural disease (►Fig. 2). The larger 11G outer cannula was advanced to the lateral pterygoid muscle and the skull base bone was breached with the inner 13G biopsy needle, both attached to the power drill. The ice ball was centered far enough from Meckel's cave that CT guidance was sufficient to monitor ice ball growth.

Patient two was a 52-year-old male with advanced right nasopharyngeal carcinoma previously treated with surgery, radiation, and chemotherapy. The tumor extended along the right trigeminal nerve to the cisternal segment with mass effect on the pons (►Fig. 3A), resulting in constant 10 out of 10 right facial pain. The patient was referred for ablation of the most proximal aspect of the trigeminal tumor for palliative pain amelioration. A path through the skull base and placement of an IceSeed cryoprobe through the drill tract was performed under CT guidance, and then the patient was transferred to MRI for monitoring of the cryoablation (6 minute freeze at 20%, 10 minute active thaw, and 7 minute freeze at 20%). Repeated imaging was performed through the procedure to ensure the edge of the ice ball did not extend into the compressed pons (►Fig. 3B). Imaging after the cryoprobe was removed showed no complication. The patient was discharged the following morning. In a follow-up discussion, one week and one month postprocedure, the patient rated the pain at a 3–4 out of 10. The patient passed away two and a half months postprocedure from systemic disease.

Discussion

This report describes the technical success and encouraging early outcomes of two cases of percutaneous MRI-guided cryoablation of perineural tumor spread along the trigeminal nerve at the skull base and involving the brain. Ablation of the targeted tumor was achieved in both patients without complication.

The most important aspect of MRI-guided cryoablation is that the precise edge of the cryoablation ice ball can be monitored as a distinct black ovoid region, particularly with MRI. Although the edge of the ice ball reflects a temperature of only zero degrees Celsius, which can be insufficient to ablate tumor cells, merely having the ice ball margin at the edge of tumor can be sufficient to result in tumor regression away from critical structures.⁷

Percutaneous MRI-guided cryoablation could therefore be used in the skull base as part of a multidisciplinary, multimodality treatment plan. First, cryoablation could be used to separate tumor from the brain to allow for safer radiation treatment. Second, cryoablation could be used for local control when the morbidity of surgery and radiation is deemed too severe, and last, cryoablation could be used for pain relief.

A major technical challenge of these procedures is the use of multimodality image guidance and related patient transfers. The image-guided operating suite at our institution has both CT and MRI capabilities with a transfer table that allows us to move a patient from CT to MRI without repositioning. Since there is no MRI-safe power drill at our institution at time of reporting and since there is better visualization of bone and drill needle with CT than MRI, drilling through the skull base is performed with CT guidance. The patient can then be moved

Fig. 3 A 52-year-old male with advanced right nasopharyngeal carcinoma previously treated with surgery, radiation, and chemotherapy presented with severe 10/10 right facial pain with disease tracking along the trigeminal nerve. (A) Axial T1-weighted SPGR post contrast image shows advanced nasopharyngeal carcinoma in the skull base with extension along the cisternal segment of the trigeminal nerve with compression of the right anterolateral contour of the pons. (B) Axial GRE image shows cryoprobe through subzygomatic approach with tip and ice ball (white arrows) in the portion of tumor compressing the pons. GRE, gradient recalled echo; SPGR, spoiled gradient recalled.

from the CT to the MRI room without repositioning for MRI monitoring of ice ball growth.

Once in the MRI scanner, it is optimal to utilize a head coil. For patient one, with the submandibular approach, the standard head coil was used with the patient in supine position. However, for patient two, the head coil would not fit due to the skin entry site in the anterior cheek. In that case, the patient was transferred directly onto the MRI table to take advantage of the body coils and a loop coil was threaded over the cryoablation cable directly onto the right side of the face to maximize signal. The loop coil alone would not have provided sufficient imaging depth and the transfer table would have interfered with signal from the body coils.

In summary, percutaneous MRI-guided cryoablation appears to be a feasible treatment option for pain palliation, local tumor control, and/or neural decompression as part of a multidisciplinary, multimodality treatment plan for patients with intracranial extension of malignancy. Further studies will be needed to determine long-term results, impact on quality of life, and appropriate patient cohort for this treatment.

Grants, Disclosures, and Other Assistance

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Institutional Review Board Statement

The study was approved by our institutional review board.

Conflict of Interest

T.C.L. reports grants from National Institutes of Health, during the conduct of the study. J.P.G. reports no personal

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