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CASE REPORT

MR-guided Laser Interstitial Thermal Therapy mesencephalotomy for medically intractable malignant pain

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Abstract

Stereotactic mesencephalotomy is a neurosurgical technique designed to sever spinothalamic pain transmission pathways for medically intractable pain. This report presents the first case of Magnetic Resonance-guided Laser Interstitial Thermal Therapy (MRgLITT) mesencephalotomy for severe malignant pain due to metastatic melanoma. The procedure significantly reduced the patient's pain, with a postoperative visual analog scale (VAS) score decreasing from > 7 to < 3. No adverse effects were observed. The case underscores the potential of MRgLITT mesencephalotomy as a precise, minimally invasive option for pain management in palliative care settings.

Keywords Mesencephalotomy · Laser Interstitial Thermal Therapy · MRI · Pain · Melanoma · Cancer

Introduction

Stereotactic mesencephalotomy, first described in the 1950 s, targets spinothalamic and trigeminothalamic pathways to manage intractable pain [4, 6, 7]. Its use declined due to morbidity associated with early methods and the rise of neuromodulation techniques [8]. However, advances in imaging and minimally invasive technologies, such as MRgLITT, have renewed interest in this procedure. MRgLITT offers real-time imaging-guided precision, making it a promising option for palliative pain management [1, 3]. This report details the first documented case of robot-assisted MRgLITT mesencephalotomy in a patient with metastatic melanoma and refractory pain.

Clinical presentation

A 47-year-old male with a history of metastatic melanoma presented with severe, treatment-resistant pain. Despite numerous therapeutic interventions, including high-dose corticosteroids, opioids, ketamine, and topical anesthetics, pain control remained inadequate. The patient's melanoma had progressed unfavorably, resulting in multiple atypical subcutaneous inflammatory and painful lesions located

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on the lower right side of the neck, the right upper limb, and the right side of the thorax and abdomen. Pain scores consistently exceeded 7 on the visual analog scale (VAS), significantly impairing quality of life. Given the refractory nature of the pain and the palliative care context, a stereotactic robot-assisted MRgLITT mesencephalotomy was proposed. The patient provided informed consent for the procedure and its subsequent publication.

Intervention and outcome

Preoperative imaging included high-resolution MRI with 3D-T1 gradient-echo sequences post-gadolinium injection, 3D-SWAN, 3D-T1 inversion recovery, and diffusion tensor imaging (DTI). These were complemented by a thin-slice CT scan. These datasets were integrated into the ROSANA planning software (Zimmer Biomet, Warsaw, IN, USA), which reformatted the images into a plane parallel to the anterior commissure-posterior commissure (AC-PC) line. Target coordinates were calculated to localize the spinothalamic tract just before its entry into the thalamus (1 mm anterior to the tangent to the mesencephalic aqueduct, 5 mm posterior to the CP, 5 mm below the CA-CP line, and 8 mm lateral). Under local anesthesia, the Leksell Series G stereotactic frame was attached to the patient's head. Using the ROSA robotic platform, a 3.2-mm burr hole was drilled at the calculated entry point. A robotic microdrive placed a microelectrode (microTargeting model 22670, FHC Inc., Bowdoin, USA) into the target, allowing macrostimulation testing at 50 Hz up to 2.5 V. Tests performed 3 mm above, at, and 3 mm below the target showed no adverse effects, confirming optimal placement. The electrode was replaced with a laser catheter (Visualase 1.65 mm with a 3-mm laser diffusing tip, Medtronic, Minneapolis, MN, USA), which was positioned to ensure a therapeutic margin while

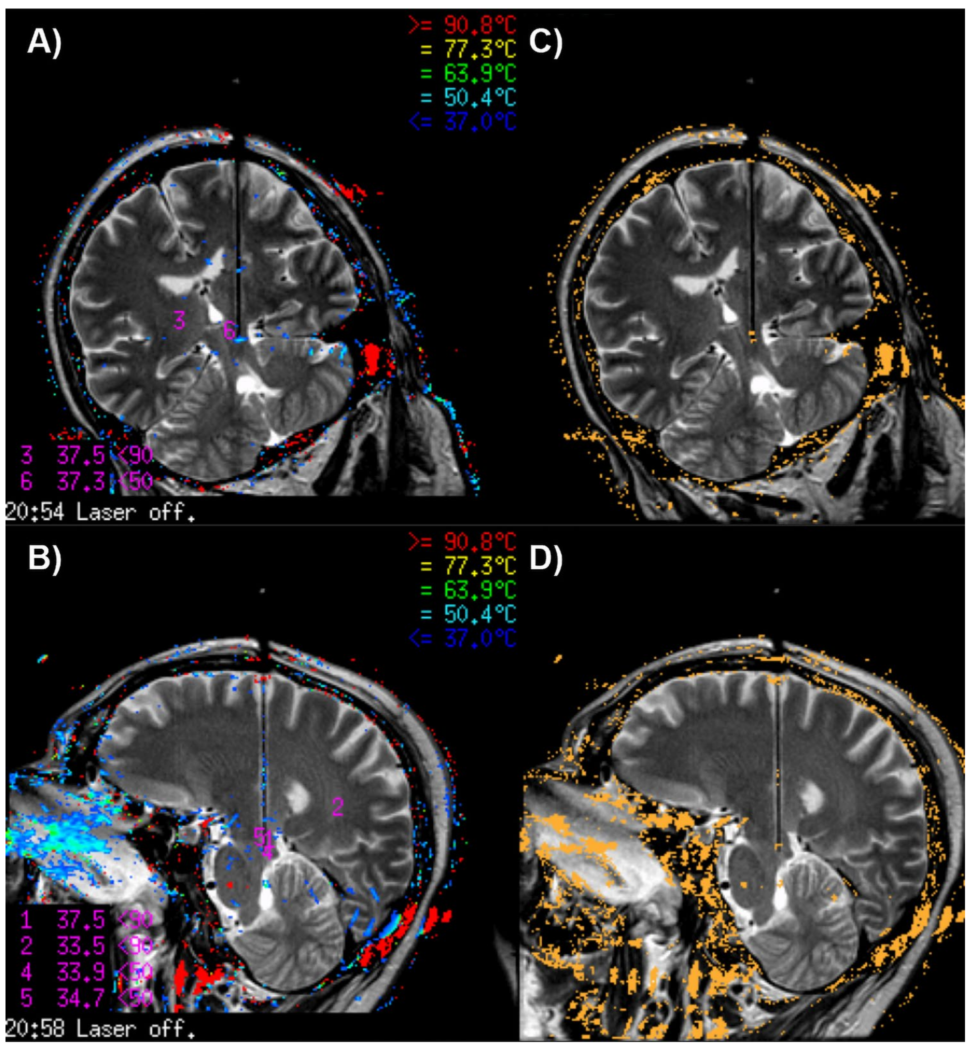

Fig. 1 Imaging during MRgLITT mesencephalotomy procedure. (**A**, **B**, blue) The thermal maps, (**C**, **D**, orange) the corresponding estimated thermal lesion in the left mesencephalon

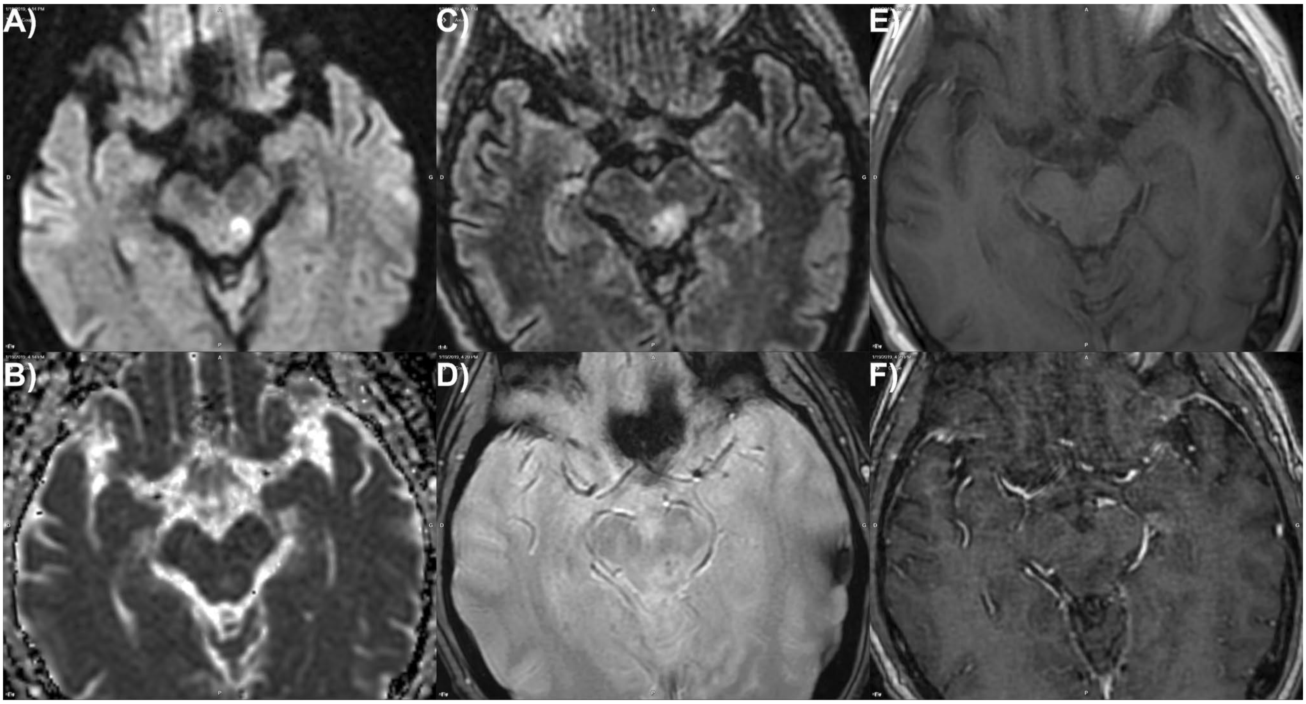

Fig. 2 MRI images at 4 days post-mesencephalotomy. **A** Diffusion-Weighted Imaging (DWI) sequence showing a hyperintense lesion indicative of restricted diffusion. **B** Apparent Diffusion Coefficient (ADC) map highlighting a central hyperintensity surrounded by a hypointense ring, suggesting central necrosis with peripheral edema. **C** T2-Weighted Fluid-Attenuated Inversion Recovery (T2 FLAIR) sequence displaying the lesion as hyperintense, along with adjacent edema. **D** Gradient Echo T2*-Weighted (T2* GRE) sequence revealing several central hypointensities, suggestive of hemorrhagic deposits at the center of the lesion. **E** T1-Weighted (T1 W) sequence revealing slight hypointensity within the lesion. **F** Post-Gadolinium T1-Weighted (T1 W+ Gd) sequence showing a hypointense lesion without contrast enhancement, consistent with the findings on the non-enhanced T1 sequence

safeguarding critical structures. Repeated flat-panel CT imaging verified the catheter's placement. With the patient under general anesthesia, the ablation probe was connected to the MRgLITT workstation in the MRI suite. Baseline thermometry images were acquired, and six safety zones were delineated to monitor temperatures during ablation. Using a stepwise approach, thermal energy was delivered at 1.0 W, 1.5 W, and 2.0 W, each for 2 min, with intervals for tissue cooling. Real-time heat maps guided the creation of a spherical ablation zone approximately 5 mm in diameter, ensuring complete lesioning of the spinothalamic tract (Fig. 1). Automatic safety cutoffs prevented overheating, and post-ablation imaging confirmed a well-defined lesion without damage to adjacent structures (Fig. 2 and 3). Postoperatively, the patient experienced significant pain relief, with VAS scores decreasing from > 7 to < 3. Temperature sensation was specifically assessed using a ice tube and a warm stimulus applied to symmetric body regions. No deficits in thermal perception were observed, indicating preserved sensory discrimination postoperatively. Opioid and adjunctive medications were substantially reduced, and no neurological deficits were observed. Unfortunately, the patient succumbed to cancer progression one month later.

Discussion

This case highlights the potential of MRgLITT mesencephalotomy in managing intractable malignant pain. Compared to historical techniques, MRgLITT provides real-time imaging guidance and precise lesioning with minimal invasiveness [2, 4, 6, 7]. Its safety profile and efficacy in reducing pain align with findings in prior literature on lesioning procedures. Alternatives such as cordotomy, total myelotomy, intrathecal baclofen, and deep brain stimulation were deemed unsuitable due to the pain's location, systemic side effects, or hardware-related risks [2, 8]. MRgLITT's ability to target specific pain pathways without systemic effects

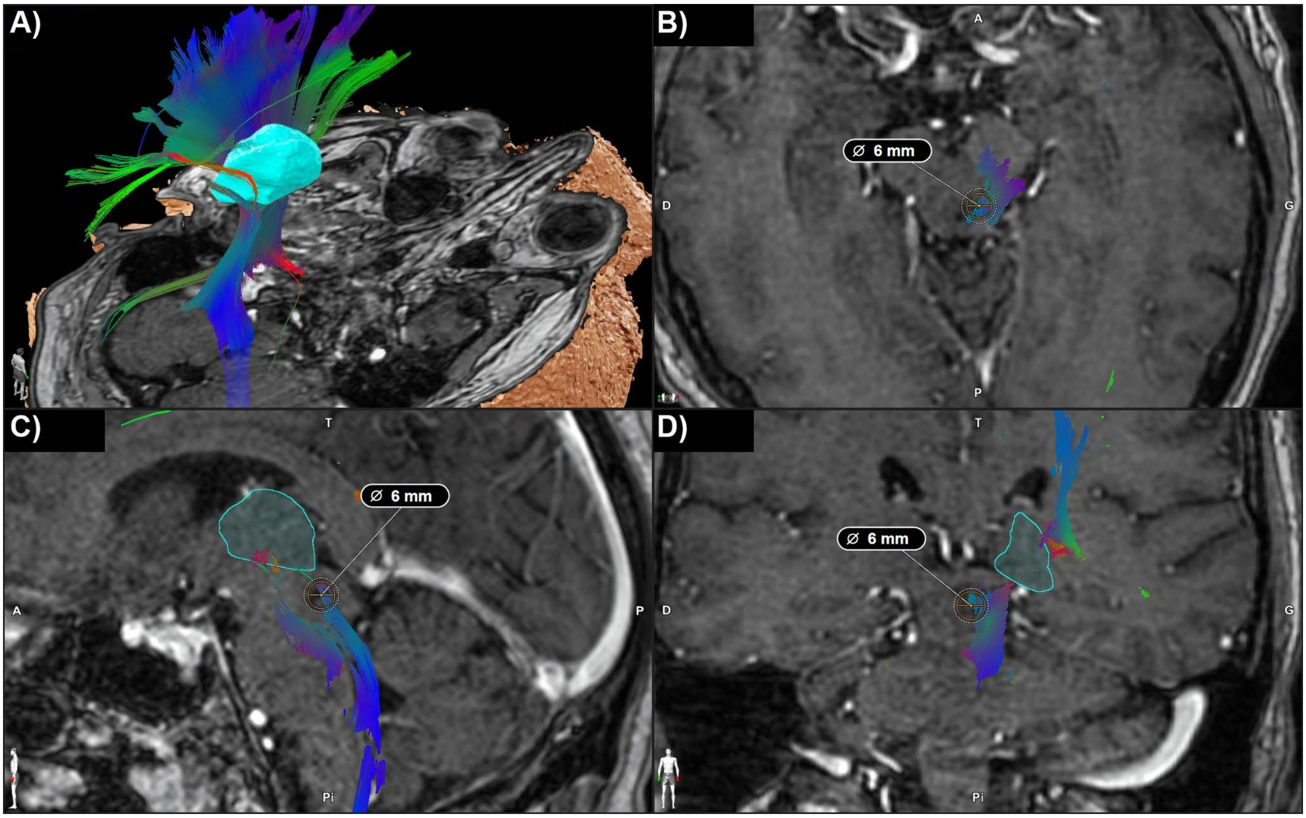

Fig. 3 Post-Gadolinium T1-Weighted MRI Images (T1 W+ Gd) showing enhanced visualization of neurological structures. The left thalamus is highlighted in cyan, with neural fibers traversing this region, depicted using Diffusion Tensor Imaging (DTI) and visualized via tractography. **A** 3D Representation: Offers a comprehensive three-dimensional visualization of the thalamus and its associated neural pathways, elucidated by DTI tractography. **B** Axial Slice. **C** Sagittal Slice. **D** Coronal Slice

makes it ideal for localized, refractory pain. This case supports the need for a multidisciplinary approach to patient selection and individualized treatment planning [5]. Future studies should evaluate long-term outcomes and broader applications of this technique.

Conclusion

MRgLITT mesencephalotomy represents a promising, minimally invasive option for managing intractable pain in palliative care settings. This case underscores its potential to improve quality of life in patients with refractory pain due to malignancy.

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Declarations

Ethical approval Not Applicable.

Consent of publication Written consent was obtained by the patient for publication.

Competing interests The authors declare no competing interests.

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