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Stereotactic needle biopsy and laser ablation of geographically distinct lesions through a novel magnetic resonance imaging–compatible cranial stereotaxic frame: illustrative case

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BACKGROUND Current technologies that support stereotactic laser ablation (SLA) of geographically distinct lesions require placement of multiple bolts or time-consuming, intertrajectory adjustments.

OBSERVATIONS Two geographically distinct nodular lesions were safely biopsied and laser ablated in a 62-year-old woman with recurrent glioblastoma using the ClearPoint Array frame, a novel magnetic resonance imaging–compatible stereotactic frame designed to support independent parallel trajectories without intertrajectory frame adjustment.

LESSONS Here, the authors provide a proof-of-principle case report demonstrating that geographically distinct lesions can be safely biopsied and ablated through parallel trajectories supported by the ClearPoint Array frame without intertrajectory adjustment.

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KEYWORDS laser ablation; stereotactic needle biopsy; glioblastoma; brain tumor

Stereotactic laser ablation (SLA), also known as laser interstitial thermal therapy, is a minimally invasive procedure whereby a laser probe is inserted into a target lesion.[1] Activation of the laser through this probe generates heat that ultimately induces protein denaturation and coagulative necrosis.[1–3] During the procedure, the laser probe is anchored through a stabilizing device designed to support a single trajectory, such as a bolt[4,5] or a stereotactic frame. And, ablation of geographically distinct lesions requires the placement of multiple bolts[6] or redirection of a stereotactic frame between trajectories.[7,8] Both of these processes can be time-consuming and may be associated with increased risk of technical errors.[9] Here, we describe biopsy/SLA of distinct, intracranial lesions through the ClearPoint Array frame,[10,11] a stereotactic device capable of supporting independent, parallel laser ablation trajectories.

The ClearPoint SmartFrame Array[10,11] is a second-generation magnetic resonance imaging (MRI)-compatible stereotactic frame (Fig. 1A). Relative to the first generation XG frame,[8] the SmartFrame Array has a more compact design and is constructed from more rigid material.[10,11] Importantly, the Array frame supports an asymmetrical cannula adaptor (Fig. 1B) that can be aligned to six distinct entry points (Fig. 1C). Rotation of this asymmetrical cannula to these predefined entry points allows the frame to support six parallel trajectories, without intertrajectory adjustment (Fig. 1D). The SmartFrame Array received U.S. Food and Drug Administration clearance for clinical use in late 2021, with a limited market release. Here, we describe the first case of laser ablation in which two geographically distinct glioblastoma foci were biopsied and ablated through the SmartFrame Array without intertrajectory adjustment.

Illustrative Case

A 62-year-old woman presented with status postresection of a right frontal glioblastoma recurrence (isocitrate dehydrogenase wild type and methylguanine-methyltransferase promoter unmethylated). Subsequent surveillance MRI revealed serial enlargement of two subcentimeter, contrast-enhancing lesions located at the right cingulate gyrus and the corpus callosum (Fig. 2A). The patient underwent a ClearPoint Array–aided biopsy and laser ablation of these two nodular lesions. Trajectory planning was carried out so that the

ABBREVIATIONS MRI = magnetic resonance imaging; SLA = stereotactic laser ablation.
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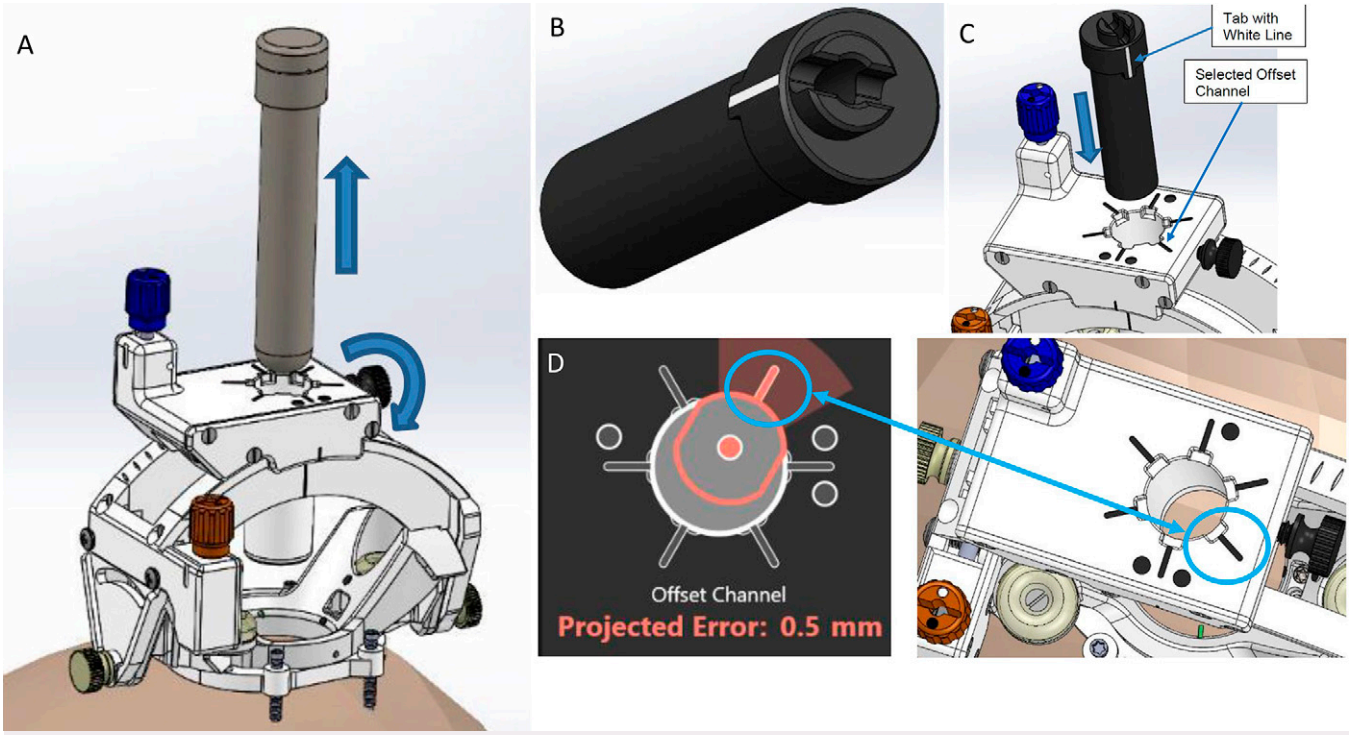

FIG. 1. A: Schematic of the ClearPoint Array stereotactic frame. **B:** Asymmetrical cannula adaptor for the ClearPoint Array frame. The orientation of the cannula is indicated by the *white line*. **C:** The asymmetrical cannula adaptor is inserted into the ClearPoint Array frame in one of six possible configurations, aligning the *white line* of the cannula with one of six potential entry points (marked with a *black marking* on the Array frame). **D:** Alignment of the cannula adapter to one of the six configurations (shown in *red*). Each configuration (shown in *light blue*) supports a unique entry point and trajectory, allowing the frame to support a total of six parallel trajectories.

two lesions could be accessed through a single Array frame mount (Fig. 2B). The asymmetrical cannula was aligned to the first trajectory. A 3-mm incision was made, followed by the creation of 3.2-mm burr holes to support this first trajectory. A stereotactic needle biopsy was inserted to biopsy the cingulate lesion, with frozen pathology demonstrating active tumor growth; final pathology confirmed this finding. The biopsy needle was replaced with a Visualase probe (Medtronic), followed by complete ablation of the contrast-enhancing cingulate lesion (Fig. 2C). The adaptor cannula was then rotated to align to the second trajectory that targeted the corpus callosal lesion (Fig. 2D) without adjustment of the Array frame itself. An incision and burr hole were created through the cannula to support the second trajectory. Needle biopsy of the corpus callosal lesion through this trajectory yielded specimens demonstrating active tumor growth (on both the frozen and final pathology). This lesion was also completely ablated. The laser probe and the frame were then removed, and the two incisions were closed with 3-0 Monocryl.

The skin-to-skin procedural time for biopsy and ablation of both lesions was 88 minutes and within the range of published single-trajectory procedural times for ClearPoint stereotaxy (138 ± 42 minutes).[10,11] Thus, the second trajectory did not add significant time relative to a single-trajectory procedure. The patient emerged from the procedure with a nonfocal neurological examination and was discharged home on postoperative day 1. Carmustine was initiated on postoperative day 3 without subsequent wound complications. There was no evidence of local recurrence at the 3-month follow-up. On the 5-month surveillance MRI after ablation (Fig. 2E), however, the patient was found to have leptomeningeal disease and was transitioned to bevacizumab therapy.

Discussion

Observations

Stereotactic laser ablation is a procedure that is gaining increasing acceptance in neuro-oncology, with an approximately 400% increase in cranial use between 2012 and 2018.[12] The available data suggest that the safety profile of laser ablation, in experienced hands, is comparable to that of a stereotactic needle biopsy.[12–14] There is increasingly compelling evidence supporting the efficacy of SLA as a treatment for primary brain cancer[2,14–16] and metastatic brain cancers.[5,17,18] An emerging theme in this literature is that the extent of ablation constitutes a major determinant of efficacy. In this context, the treatment of multifocal neoplastic diseases, exemplified by the case presented here, presents a technical challenge. For these tumors, multiple anchoring devices or time-consuming adjustments[5] of a stereotactic frame is required.[19] The design of the ClearPoint Array stereotactic frame offers one potential solution to this technical challenge, allowing lesions targetable by parallel trajectories to be treated through a single stereotactic frame mount without the need for multiple bolts or intertrajectory adjustments. Our case report provides proof of principle that multiple intracranial lesions can be safely biopsied and laser ablated using the ClearPoint Array frame. Because the ClearPoint Array frame is MRI compatible, the procedure can be performed under real-time MRI guidance.

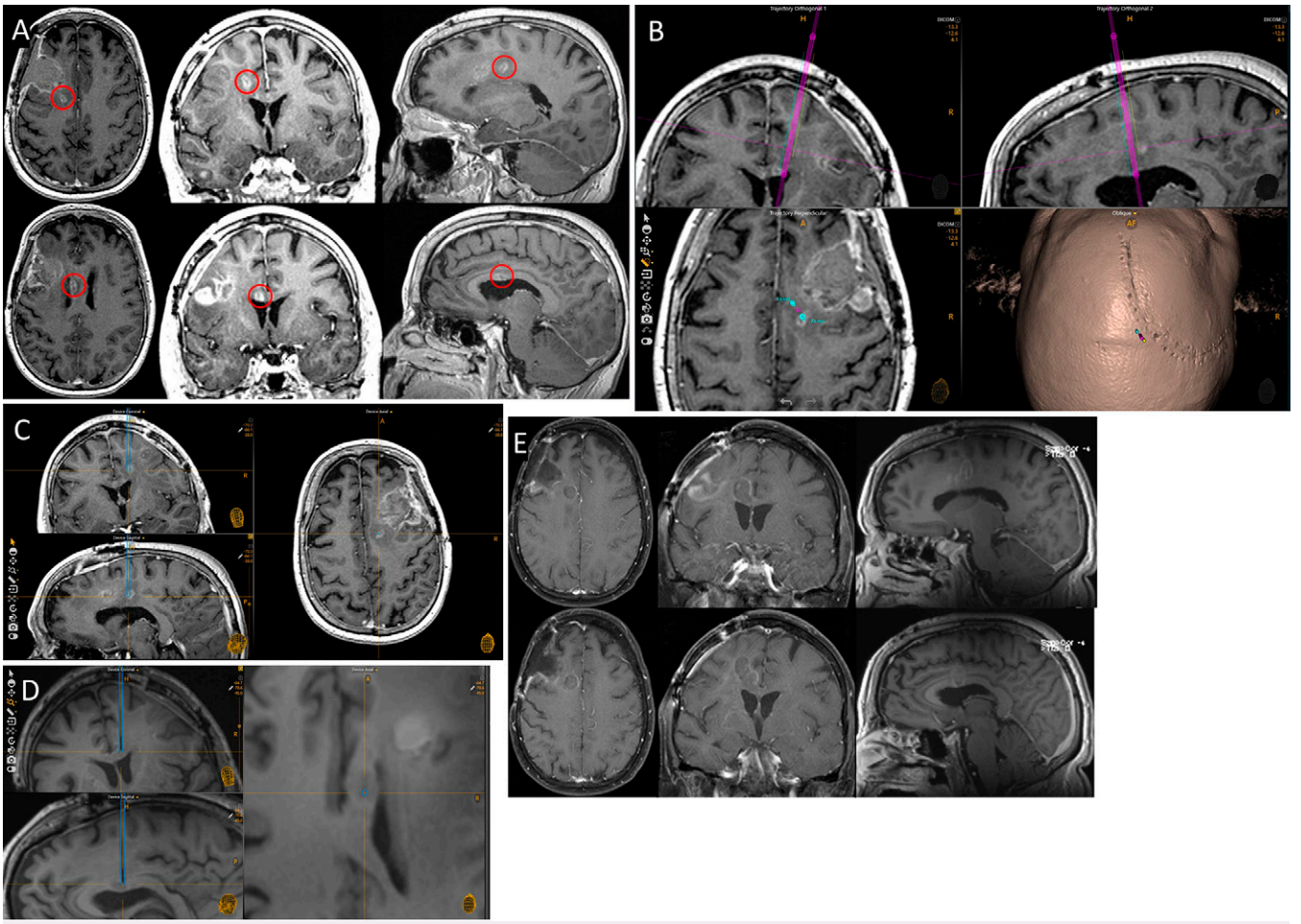

FIG. 2. A: Axial (*left*), coronal (*middle*), and sagittal (*right*) MRI of the brain showing two new nodular lesions, located at the right cingulate gyrus (*upper*) and the corpus callosum (*lower*). The *red circle* highlights the nodular lesions. **B:** Trajectory planning showing access to two lesions through the ClearPoint Array frame. Coronal (*upper left*), sagittal (*upper right*), axial (*lower left*), and surface rendering (*lower right*) of the planning MRI. The *pink line* indicates the midpoint between the two planned trajectories. The *light blue lines* indicate the actual, parallel trajectories to the cingulate and the corpus callosum lesions. **C:** The cingulate gyrus lesion was biopsied and treated with SLA with a $<$1.4-mm radial error. The entire contrast enhancement was ablated. Coronal (*upper left*), sagittal (*lower left*), axial (*right*) views of the planning MRI. The *blue outline* defines the trajectory to the cingulate lesion. **D:** The corpus callosum lesion was biopsied and treated with SLA with a $<$0.8-mm radial error. The entire contrast enhancement was ablated. Coronal (*upper left*), sagittal (*lower left*), axial (*right*) views of the intraoperative MRI studies obtained after laser probe insertion. The *blue outline* defines the trajectory to the corpus callosum lesion. **E:** MRI of the brain performed 3 months after SLA showing local control of the cingulate gyrus lesion (*upper*) and corpus callosum lesion (*lower*).

Lessons

To our knowledge, this case represents the first in the literature documenting the capacity of the ClearPoint Array to support multiple stereotactic trajectories without intertrajectory frame adjustment. We believe that this frame adds to the surgeon's ability to perform stereotactic procedures targeting geographically distinct lesions. Admittedly, the current Array design is limited by the distance between parallel trajectories (a maximum of 6 mm). Future modifications that increase this distance can further enhance the versatility of this frame.

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Author Contributions

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

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