

Man vs. Machine: Can AI Rival Neurosurgeons in Targeting the VIM for Focused Ultrasound Thalamotomy?

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ABSTRACT

BACKGROUND

Transcranial MRI-guided focused ultrasound (MRgFUS) thalamotomy is an established, incisionless treatment for essential tremor (ET). Precise targeting of the ventral intermediate nucleus (VIM) is critical for efficacy but remains challenging, as the VIM is not directly visible on MRI and must be estimated using anatomical landmarks. Inaccurate targeting can lead to off-target lesions and long-term sensory complications, such as persistent numbness, highlighting the need for more reliable targeting strategies.

OBJECTIVE

To compare the accuracy of RebrAln's OptimMRI, an automated machine learning targeting algorithm, with traditional neurosurgical targeting methods in patients who developed persistent numbness following MRgFUS thalamotomy for essential tremor.

METHODS

We retrospectively analyzed 11 patients who developed persistent numbness after MRgFUS thalamotomy for essential tremor. For each case, we recorded the neurosurgeon's original target coordinates and the final lesion location on post-procedure imaging. RebrAln's OptimMRI was then used to generate an automated VIM target for each patient. Targeting accuracy was assessed by comparing the Y-axis deviation between the AI-predicted target and the final lesion site.

RESULTS

AI-generated targets consistently differed from the final lesion sites, with most cases showing an anterior shift relative to the lesions. This difference in targeting was observed in nearly all patients who developed persistent numbness.

CONCLUSION

These findings suggest that AI-based targeting identifies systematically different lesion sites compared to neurosurgical planning in patients with long-term sensory side effects. Automated approaches like RebrAln's OptimMRI may offer opportunities to optimize target selection and potentially reduce the risk of persistent numbness following MRgFUS thalamotomy.

OBJECTIVES

Transcranial MRI-guided focused ultrasound (MRgFUS) thalamotomy is an effective treatment for essential tremor ET but can be complicated by long-term sensory side effects such as numbness. Precise targeting of the ventral intermediate nucleus (VIM) is crucial, but variability in anatomy and human planning can result in off-target lesions and adverse events.

OptimMRI, a machine learning algorithm from RebrAln, uses 18 anatomical landmarks per hemisphere for automated VIM targeting, trained on successful MRgFUS cases. Its ability to match or exceed expert neurosurgeon targeting—especially in challenging cases with long-term side effects—remains untested.

METHODS

We retrospectively analyzed 11 patients who underwent difficult treatments and developed persistent numbness following MRgFUS thalamotomy for essential tremor. For each case, we recorded the neurosurgeon's original target coordinates and the final lesion location from post-procedure imaging. We then applied RebrAln's OptimMRI, to generate an automated VIM target for each patient. Targeting accuracy was assessed by comparing the Y-axis deviation between the lesion site and the AI-predicted target.

RESULTS

Among 11 patients with persistent numbness, the mean Y coordinate of the final lesion was 7.0 mm anterior to the posterior commissure (PC) (range: 4.74–8.7), while the mean Y coordinate of the AI-predicted (RebrAln) target was 7.77 mm anterior to PC (range: 6.05–8.61). The mean difference in Y position between the AI-predicted and lesion sites was +0.78 mm (SD: 0.61), indicating that the AI consistently targeted a more anterior location compared to the actual lesion in nearly all cases. Only one case showed a posterior (negative) difference, while the remaining ten showed anterior (positive) shifts. These results suggest that automated AI targeting may systematically identify VIM targets anterior to those ultimately lesioned in patients who develop long-term numbness following MRgFUS thalamotomy.

FIGURES

FIGURE 1

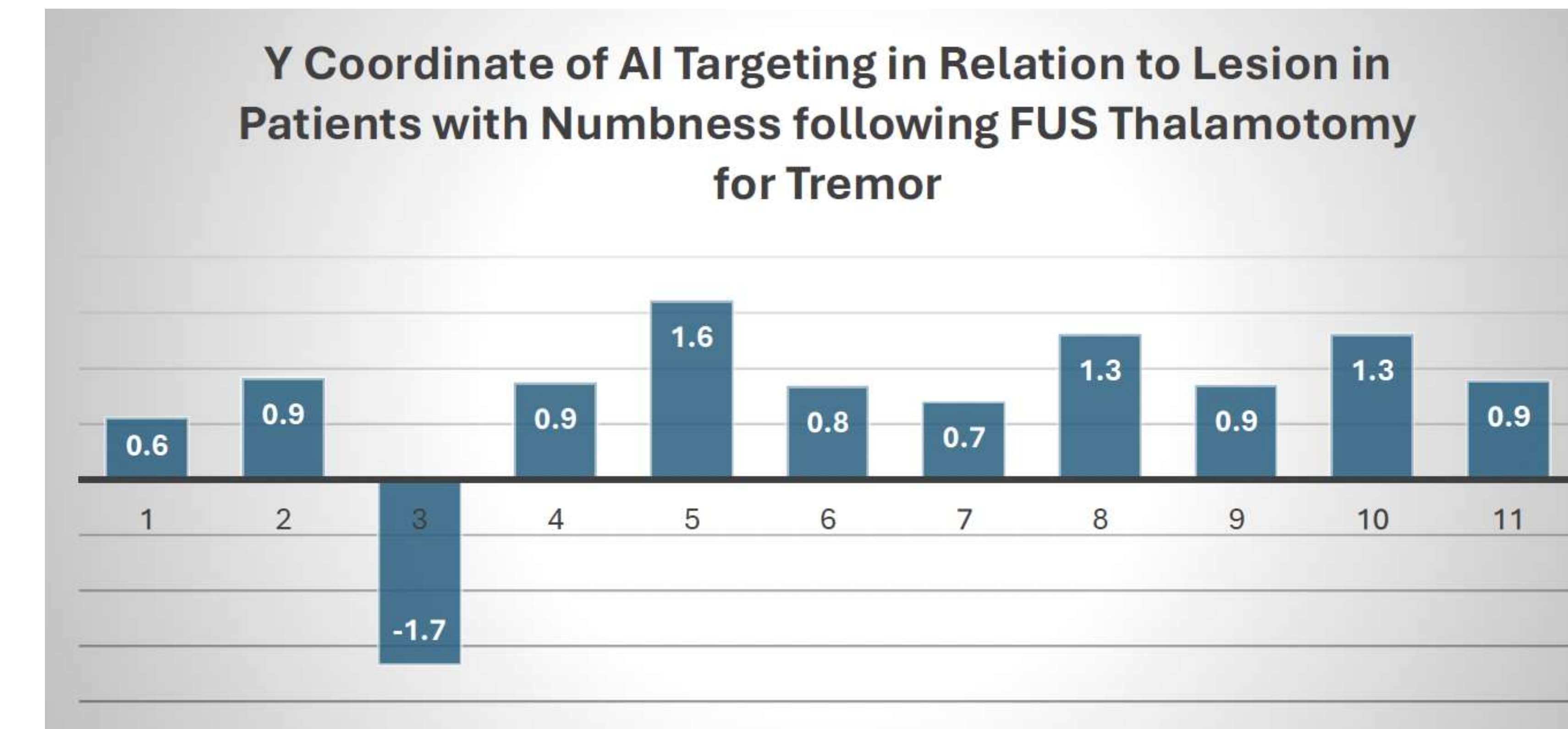
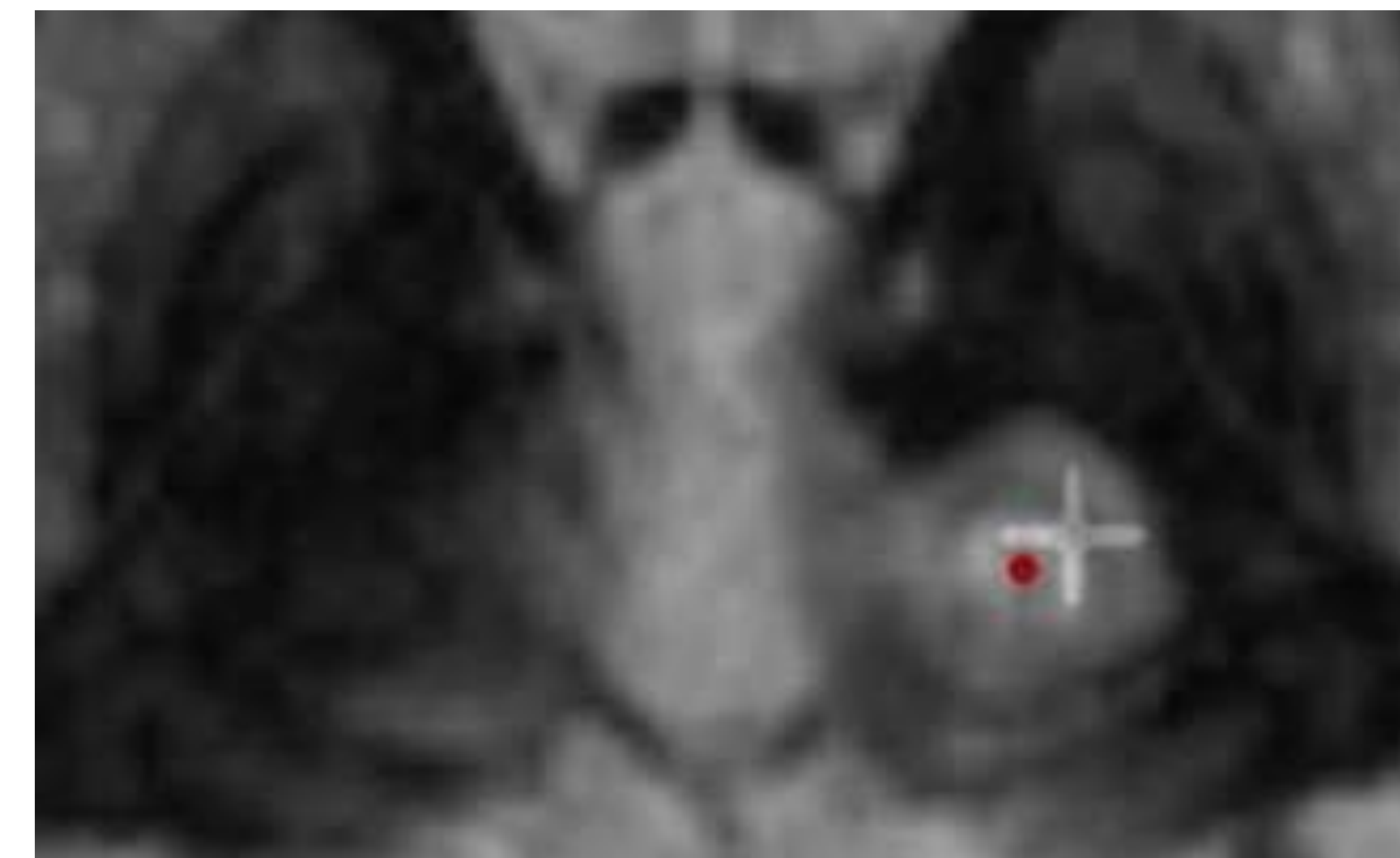


FIGURE 2



Axial FGATIR MRI demonstrating AI-predicted target (marked by plus sign) that is anterolateral to thalamotomy lesion (center marked by red dot) in a patient with persistent dysgeusia one year after surgery.

DISCUSSION

These findings suggest that AI-guided targeting may offer an alternative approach to reduce the risk of long-term sensory side effects in MRgFUS thalamotomy. In this study, AI-targeting predicted anterior lesioning in almost all patients who developed numbness, which would be expected as the sensory thalamus is just posterior to the VIM. Incorporating machine learning into surgical planning could help standardize lesion placement and minimize variability due to human estimation. Future studies with larger, prospective cohorts are needed to determine whether AI-driven targeting improves patient outcomes and reduces complications such as persistent numbness.

CONCLUSIONS

Persistent numbness after MRgFUS thalamotomy remains a challenging complication, and current targeting methods may not always prevent it. Our findings indicate that AI-assisted targeting, like RebrAln's OptimMRI, can provide an additional perspective that may help guide lesion placement more precisely. Rather than replacing clinical judgment, these tools can complement the expertise of neurosurgeons by offering objective, data-driven guidance based on a large set of prior cases. Ultimately, integrating AI into surgical planning could help reduce variability in outcomes and improve patient safety.

REFERENCES

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