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Modelling Dosimetric Impact of Target Rotations for Trigeminal Neuralgia in Robotic Stereotactic Radiosurgery

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Abstract
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Abstract

Objectives:

In radiosurgery for trigeminal neuralgia, the dose delivered to the trigeminal nerve (CN5) is significantly higher than the dose tolerance of the brainstem which is only a few millimeters from the target. The impact of uncorrected rotational setup error on the length of CN5 receiving the prescription dose as well as dose received by the brainstem is evaluated for robotic radiosurgery.

Methods:

A proposed model estimates delivered dose considering rotational setup errors. The model is validated using radiochromic film measurements. The length of CN5 encompassed by the prescription isodose volume and the brainstem dose is retrospectively assessed for 24 treatments (21 first treatments, 3 retreatments). The robot moves the linac around the patient along paths specialized for different anatomy and tracking modalities. Most intracranial treatments use the head path, in which the system can correct for small rotations. The trigeminal path brings the linac closer to the patient to provide a steeper dose falloff away from the nerve but rotational corrections are not applied to avoid potential collisions with the patient. Case studies illustrate how an acceptable range of rotations can be determined that meet the treatment goal (treated length ⩾ 4.0 mm) and dose constraints of the brainstem when rotations are not corrected for the trigeminal path.

Results:

In the experimental validations, the measured dose agrees with the estimated dose at the 1%/1 mm level. For a small target within a high dose gradient an uncorrected rotation can make a significant difference in dose delivery. For 24 treatments, the treated length is reduced from 5.9 ± 1.8 mm to 5.3 ± 1.7 mm and dose constraints for the brainstem are met for 23 cases if rotations (< 0.5 deg) are uncorrected. The treated length of CN5 and plan quality metrics are very similar for the two beam paths. Using the case studies, we demonstrate that our model provides a patient-specific tolerance of rotations allowed for treatment.

Conclusion(s):

Uncorrected rotations of < 1 deg can be safe for some patients. The dosimetric impact of rotation on the treated length and the brainstem dose can be assessed using our model on a patient-specific basis, which provides insight on the toxicity and effectiveness of the different paths.