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Impact of penumbra sharpness on lateral margin requirement for ocular proton therapy

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Purpose
Ocular malignancies are treated worldwide with proton therapy using a diverse set of accelerator delivery systems. Lateral margin usage remains consistent, despite variations in dose characteristics. This study quantifies the interchangeability of lateral margin and penumbra sharpness in ocular proton therapy, addressing a key treatment optimization factor.

Methods
In this study, we investigate permissible offsets to the intended clinical eye orientation by assessing resulting target coverage for a cohort of 16 patients. Using a point cloud model of the eye, we applied translations and measured translation-induced rotations to identify the three-dimensional boundary conditions which ensures adequate target coverage. We explored a range of lateral margins and dose penumbras, as reported from different operational treatment facilities around the world.

Results
Our investigation defines a range of offsets for the investigated cohort within which target coverage is preserved for the investigated lateral margins and penumbras. Initial findings utilizing the dose field characteristics of the Optis treatment room at Paul Scherrer Institut in Switzerland, indicate that target coverage for all patients would remain uncompromised even for deviations within 0.5 mm, 0.5 mm, and 1.5 mm along the x, y, and z axes of the treatment room. In contrast, the cohort-wide median representation showed values of 1.0, 1.0, and 2.8 in the x, y, and z dimensions, respectively. The findings indicate that the comparable offset tolerance for a given treatment facility can be calculated using the equation: Lateral margin = $1.6 * x + 0.9$, where x represents the ratio of representative penumbra sharpness of the facility over that of Optis.

Conclusion
Our results establish a benchmark for selecting appropriate lateral margins based on the dose characteristics specific to the treatment facility, ensuring equivalent robustness between facilities to errors in patient positioning and intra-fractional motion

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