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Analysis of Plan Analytics Data for Multiple Brain Metastases Treatment Planning in SRS

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Purpose

One step towards automated treatment planning in stereotactic radiosurgery (SRS) is the standardization of dose planning to achieve high-quality plans regardless of clinic and patient specific characteristics [1].
The objective of this work was to analyze geometric, treatment and plan parameters of clinical Plan Analytics Data (PAD) from different institutions to identify differences and correlations in the SRS treatment planning landscape for multiple brain metastases.

Materials and Methods

Retrospective datasets from six clinics with a total of 451 approved treatment plans and 2,077 target volumes were investigated. The plans were created with Multiple Brain Mets SRS (Brainlab AG, Munich, Germany) treatment planning software and extracted as DICOM-based PAD to process plan meta data with an internal Python-based function library.
Statistical methods like the Kruskal-Wallis rank sum test, Pearson's correlation coefficient and a Bonferroni correction were applied to analyze the distributions and correlations as well as differences in

- Geometric (e.g., size and shape of a metastasis),
- Treatment (e.g., fractionation and prescription dose) and
- Quality (e.g., local Vx, CI and GI)

characteristics of single lesions between all institutions.
Furthermore, machine learning (ML) was used to determine whether outcome for single metastases (i.e., local CI and GI, bridging dose and local $V_{50\%}$) can be predicted based on lesion geometry and treatment parameters. For this, various regression models were trained and evaluated with the available PAD.

Results

The results of the Kruskal-Wallis rank sum test showed significant differences in lesion geometry and treatment parameters between the institutions (Figure 1). Also, resulting quality characteristics for single metastases differed significantly from clinic to clinic.
Some of the geometric and treatment parameters (e.g., volume, convexity and prescription dose of a lesion) were highly correlating with quality characteristics like local CI and $V_{50\%}$.
The resulting R^2 scores of the ML models for the prediction of outcome parameters for single lesions ranged from 0.5 to 0.9. Figure 2 shows the predicted values compared to the actual values for local CI.

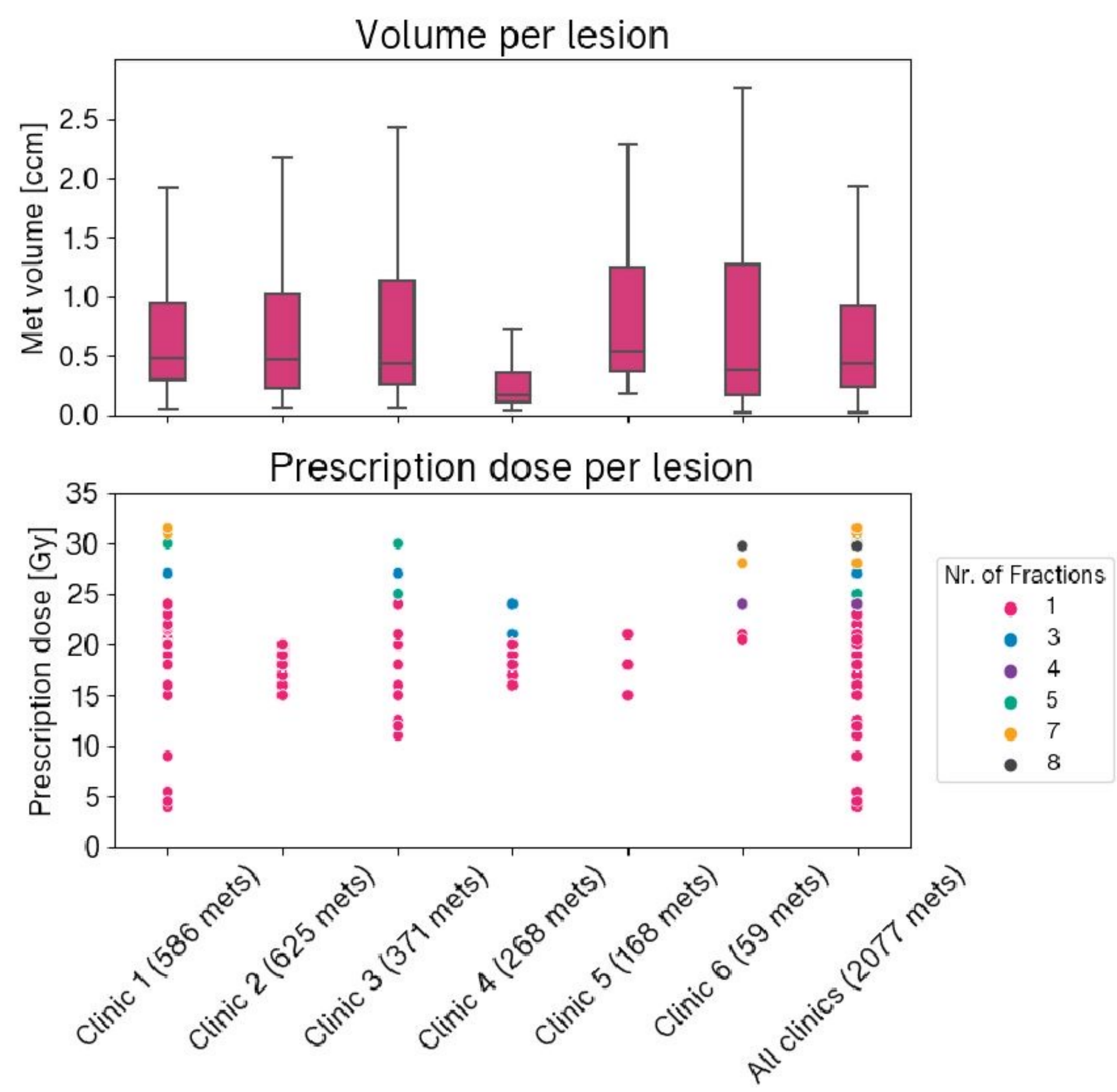

Figure 1: Distribution of lesion volume and prescription per clinic.

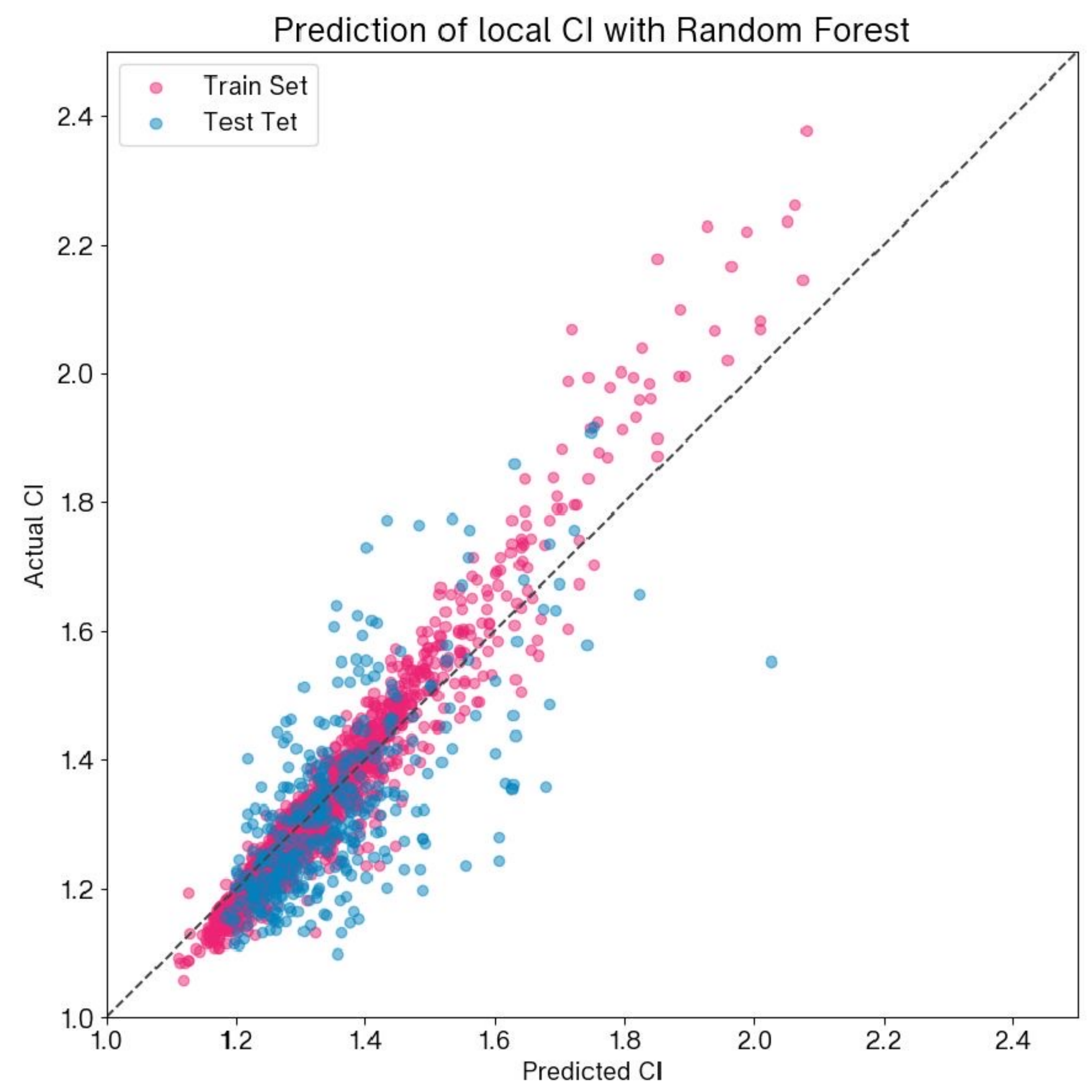

Figure 2: Prediction results for local CI.

Conclusion

To further automate treatment planning in SRS, model based optimization can support clinical trade-off decisions like delivery efficiency vs. dosimetric outcome. The results of the PAD analysis show that both input and outcome of treatment plans differ significantly between multiple institutions. With increasing number of data from different clinics, models can be developed to further drive standardization in SRS treatment planning while accounting for personalized treatment decisions.

References

[1] Teruel JR, Malin M, Liu EK et al. (2020) Full automation of spinal stereotactic radiosurgery and stereotactic body radiation therapy treatment planning using Varian Eclipse scripting. Journal of Applied Clinical Medical Physics 21:122–131. https://doi.org/10.1002/acm2.13017