Assessment of the Efficiency Index in Stereotactic Radiosurgery Planning

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Purpose

The efficiency index ($\eta_{50\%}$ for single target and $G_{\eta 12Gy}$ for multi-target plan) is a novel parameter used to quantify plan quality that combines conformity, gradient, and mean dose into a single value. The purpose of this study was to evaluate this index in patients treated for multiple clinical scenarios, including single fraction radiosurgery (SRS), hypofractionated stereotactic radiotherapy (SRT), single target plans (STP), multi-target plans (MTP).

Methods & Materials

Treatment parameters, including Paddick conformity index (PCI), gradient index (GI), mean dose (MD), and efficiency index ($h_{50\%}$ and G_{h12Gy}) were calculated from 224 stereotactic radiosurgery treatment plans for patients treated between July 2017 and May 2019. 187 plans were SRS and 37 were SRT with 108 as STP and 116 as MTP. Correlation between each of the treatment parameters was performed.

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Novel stereotactic radiosurgery treatment parameter, efficiency index has been retrospectively analyzed for multiple clinical SRS/SRT scenarios. This dosimetric analysis provides comparison and acceptable range of this parameter for clinically approved plans. For lesions smaller than 1.5 cc, this parameter ranges highly from 0.1 to 0.5 and cannot be used as a reliable quality index. For lesions lager than 1.5 cc, an average efficiency index of 43% was noted. Figures 1 and 2 show the Efficiency index, η50%, and the PCI as a function of the treated volume (cc) for SRS and SRT plans. Figure 3 and 4 show the corresponding η50%, and GI for the same group. Direct correlation of the efficiency index with PCI and inverse correlation with GI can be seen in the figures presented below.

Figure 1. Efficiency Index $\eta_{50\%}$ and PCI vs Volume (cc) for Single Target Plan SRS treatments

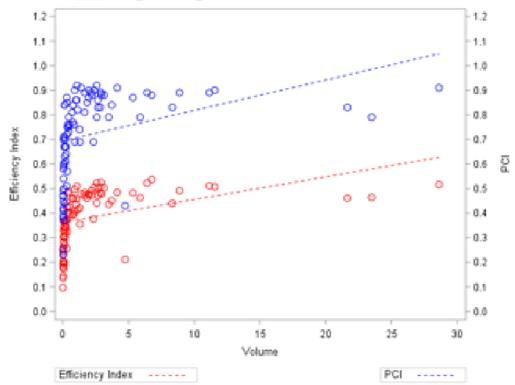


Figure 2. Efficiency Index $\eta_{50\%}$ and PCI vs Volume (cc) for Single Target Plan SRT treatments

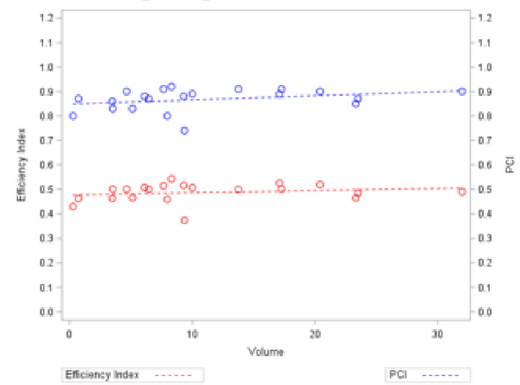


Figure 3. Efficiency Index $\eta_{50\%}$ and GI vs Volume (cc) for Single Target Plan SRS treatments

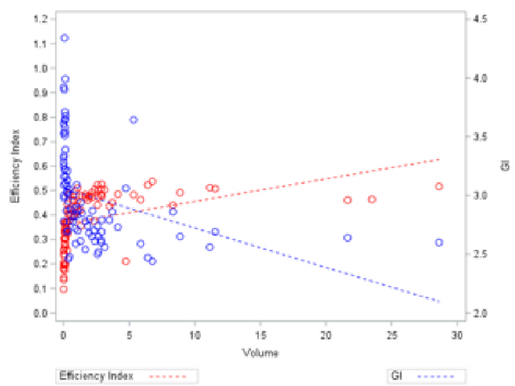
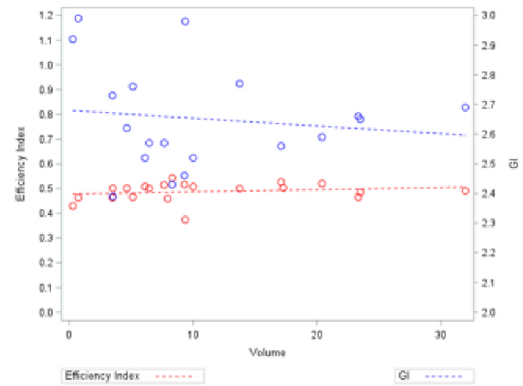


Figure 4. Efficiency Index $\eta_{50\%}$ and GI vs Volume (cc) for Single Target Plan SRT treatments



Results

During the treatment period, 224 patients were treated to 758 brain lesions. The median maximum diameter was 1.3 cm (Range: 0.2-5.4 cm) and the median volume was 0.79 cc (Range: 0.004-35.4 cc). Efficiency indices were noted to be highly variable for lesions < 1.5 cc. For lesions >1.5 cc, for STP, $\eta_{50\%}$ range from 21.1% to 53.7%, with a mean of 47.4% for SRS, and a range of 37.4% to 54.3% with a mean of 48.7% for SRT cases. The corresponding MTP efficiency index ($G_{\eta 12Gy}$) for SRS cases range from 25.2% to 73% with a mean of 46.4%, and a range from 36.5% to 54.3% with a mean of 43.40% for SRT cases. Results indicate a similar trend for $\eta_{50\%}$, and PCI for single target plans treated. Since PCI and GI are determined for each lesion, it is not possible to determine the same trend for MTP.

Conclusion

This study represents the dosimetric analysis of a novel stereotactic radiosurgery treatment parameter, efficiency index, in a cohort of patients treated for brain metastasis.