Use of a novel multi-criteria optimization algorithm in a commercially available treatment planning system to evaluate organ at risk sparing

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Purpose

To evaluate the benefit of the new Eclipse TPS multi-criteria optimization (MCO) on clinical VMAT head and neck plans and to determine if organs at risk (OARs) could be further spared compared to clinical treatment plans produced without MCO.

Methods/Materials

The Eclipse MCO features currently under evaluation enable the user to explore the plan optimization solution space and perform real-time trade-off analysis for a selected set of structures. We hypothesize that utilizing MCO navigation after a plan is manually optimized will yield a net improvement in DVH metrics (hence referred to as “free dose”). Specifically, OARs will show a decrease in dose and target volumes will show an increase in homogeneity when compared to the initial plan without a compromise to initial plan quality. We performed the MCO trade-off analysis on eleven previously treated head and neck VMAT plans to search for free dose. The plans selected contained the same prescription (simultaneous integrated boost of 70Gy, 63Gy, and 56Gy), coverage requirements (100% of the PTVs receiving 95% of the prescribed dose), and normal tissue constraints. The initial plans and MCO plans were both normalized to the same coverage (100% dose covers 95% of target volume). DVH metrics for all targets and normal tissue structures (including structures not selected for MCO) were analyzed to determine which clinical objectives were met.

Results & Discussion

Of the eight normal tissue structures selected for MCO navigation, three went from initially failing to meet a given clinical objective, on average, to passing the clinical objective with the use of MCO. This improvement in plan quality with MCO was achieved without causing any structures, used in navigation or not, to fail to meet a clinical objective after initially passing the objective (Figure 1). In addition, the coverage of each dose level PTV and max dose were not significantly compromised during the MCO process. In fact, the max dose of the overall plan was reduced by 0.39 Gy ±0.85. All of the navigated plans maintained acceptable clinical coverage and max dose as seen in Figure 2.

Conclusion

Analysis of the DVH metrics supports our hypothesis that clinically treated plans can be improved when MCO navigation is utilized during the treatment planning process. MCO proves a useful tool for evaluating trade-offs between target volume and normal tissue DVH metrics and demonstrates the potential to produce clinically superior treatment plans for a given set of plan parameters.

Figure 3: A combined column chart comparing each relevant clinical objective comparing the clinically treated plan (blue) to the MCO navigated plan (yellow). Error bars present on each column represent two standard deviations. The clinical objectives are ordered from largest decrease in dose to largest increase in dose. *The Y-axis units are in Gy, except for the clinical objectives requesting percent for evaluation.

Figure 2: A summary table of the organs at risk sorted by greatest negative change to greatest positive change. Green highlights show the objectives and structures that were met after navigation, but had not been met in the clinical plan.