Switching From Type B to Type C Dose Calculation Algorithm: Maintaining Treatment Planning Continuity in Head and Neck Treatments

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### RATIONALE
- We operate a robust Head and Neck radiotherapy program with over 800 patients treated to date
- We adhere to stringent planning goals, with the PTV volume V-0.03cc covered by 95% of the prescription dose (Rx), GTV volume V-0.03 cc covered by 100% of the Rx, and the hot spot to a single voxel (D$_{0.03cc}$) limited to 105% of Rx, among others
  - Such a tight D$_{max}$ goal is not common and corresponds to the often-quoted Homogeneity Index $HI = (D_{2\%} - D_{98\%})/D_{50\%}$ of 0.05±0.01, or one-half of typically reported value of ~0.1.
- We compared the rates of reactive placement of, and long-term dependence on, percutaneous endoscopic gastrostomy (PEG) tubes in our series to other published outcomes:
  - Data hints at reduced PEG dependence in comparison with the pooled photon chemoradiation series and equivalency to the preliminary proton (IMPT) results
- Recently, we have undertaken an across-the-board switch of the main treatment planning algorithm from Type B Collapsed Cone (CC) to Type C Monte Carlo (MC)
- Given excellent clinical outcomes, it was imperative to demonstrate dosimetric equivalency between the historical (CC) and new (MC) treatment plans, which precipitated this project
- It is not known which part of our approach lead to the apparent trend in clinical results. Therefore, absent evidence to the contrary, it is important to reproduce every detail as much as possible, including the interrelated target dose coverage and inhomogeneity parameters

### FINDINGS
- Statistical “blurring” of the DVH can be avoided with the studied commercial implementation of MC simulations. It is feasible to evaluate single-voxel hot spots, as we did with CC:
  - Calculations with 0.3% statistical uncertainty ($\sigma$) take only 46-134 s, for the primary PTV volumes 37-109 cc
  - Considering a DVH with $\sigma$=0.1% noise-free, the one with $\sigma$=0.3% is effectively the same
  - Average D$_{0.03cc}$ was nominally higher for MC vs. CC (106.0±1.2% vs. 104.8±0.5%, p<0.0001)
  - 95% CI for MC demonstrates that in majority of cases D$_{0.03cc}$ ≤107% is possible with the same target coverage
  - It is an improvement in real terms, as the 95% CI for original CC plans simply recalculated with MC was 108%
  - OAR sparing was not significantly different
  - Primary PTV isodose coverage was slightly more conformal for CC vs. MC (100% isodose relative volume of regret 0.23 vs. 0.3, p=0.002)
  - Mean dose to Mandible in PTV was 2.4% lower
  - Precision HN planning was smoothly transitioned to the MC algorithm preserving the parameters of care

### METHODS
- Twenty-one Pinnacle (Philips Medical Systems, Fitchburg, WI) CC plans previously used to treat oropharyngolaryngeal cancer were recalculated “as is” with RayStation (RaySearch Laboratories AB, Stockholm, Sweden) MC algorithm
- Same plans were reoptimized in RayStation using both CC and MC algorithms
- All plans were calculated on a 3 mm isotropic grid and normalized so that at least 95% of each PTV received at least its prescription dose
- An attempt was made to bring the dose reported by the intermediate pencil beam algorithm closer to dose-to-tissue by voxel-wise multiplication by $(\sigma^2/\mu)^m$
  - (No improvement in planning was seen)
- OAR sparing was evaluated by the combined plan quality metric
- Dosimetric indices averages were tested for statistically significant differences by ANOVA with subsequent pair-wise analysis

### REFERENCES

![PTV DVH calculated with different $\sigma$](image)

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