Assessment of plan quality variability in Head and Neck treatments using feasibility predictions in a commercial software

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INTRODUCTION

Treatment planning and optimization is an iterative and time consuming task coupled with the plan quality variability[1]. Even the clinically accepted plans for the same treatment site and institution differ in plan quality specifically in OAR sparing. The variability in the plan quality was previously attributed to the inter-planner skills[2]. Many different solutions have been proposed to automate the treatment plan optimization to achieve superior quality plans and to reduce the inter-planner variability[3,4]. Recently a Feasibility DVH (*f*-DVH) tool[5] was integrated in Pinnacle treatment planning system to facilitate the autoplanning module. This work investigates the usability of *f*-DVH integrated autoplanning tool for HN cases.

AIM

This study was aimed to:

1. Assess and reduce the variability in plan quality for Head and Neck (HN) treatments among different centers of our department using a commercial feasibility prediction tool.
2. Investigate the suitability of feasibility DVH (*f*-DVH) guided auto-planning in Pinnacle treatment planning system for complex HN cancer sites.

METHOD

- A total of 109 HN plans treated between 2017-2019 were selected for this study, with 52 plans from the main and 57 from regional centers. All plans were having primary target volumes and bilateral lymph nodes treated with a prescription of 70 Gy and 56 Gy respectively.
- The DICOM data (CT images, RT-Structures and RT dose) for each plan were imported into the commercial software PlanIQ (Sun Nuclear Corporation, Melbourne, FL.) for feasibility benchmark dose calculations. The benchmark dose predicted DVHs for OARs at various feasibility levels (*f*-value) with lower *f*-values indicating superior OAR sparing and increasing difficulty to achieve in real treatment planning.
- DVHs from clinical plans for ten OARs were compared to the feasibility DVHs with *f*-value ranging from 0.0-0.5. *f*-values were sampled for maximum Dice coefficient.
- In next phase of this study, ten patients were selected from the regional sites for feasibility DVH guided re-planning using the auto-planning tool. Feasibility DVHs were used as inputs for dose objectives in the optimizer.
- After the first run through autoplanning optimization, manual optimization was performed to achieve the clinical objectives.
- The plan quality was compared using the institutional clinical criteria applied in score cards. The differences, from clinical plans in *f*-values and dosimetric endpoints for each OAR were calculated as **Δ = (clinical value – replan value)**
- Wilcoxon rank sum test was used for statistical analysis.

RESULTS

- For the entire sample, the mean *f*-values were 0.27±0.14 and 0.35±0.16 for main and regional plans respectively.
- The noticeable differences in mean *f*-values, between main and regional centers, were observed for almost all OARs situated medially (spinal cord, larynx, supraglottis, trachea and esophagus) indicating potential for further sparing. (Table 1, first two columns)
- The median *f*-values were statistically different (*p*-value < 0.05) for all OARs except left parotid.
- For the ten re-planned cases, the overall mean *f*-value decreased from 0.35±0.16 to 0.25 ±0.13 resulting in superior OARs sparing with similar dose coverage to the tumor volumes.
- Noticeable differences in *f*-values and respective dosimetric endpoints between the re-plans and clinical plans were observed for spinal cord, esophagus, larynx, supraglottis and trachea as described in the last two columns of table1 and an isodose distribution example along with the DVH comparison from a planning dataset is shown in figure 1. The figure shows a **15.4 Gy** difference in maximum dose to spinal cord.
- The least mean differences in f-values and dosimetric endpoints were observed for parotids and oral cavity.
- F-DVH guided autoplanning time was observed within the clinical time scale allotted for a complex HN treatment planning.

Table 1: Descriptive statistics for the selected OARs. First two data columns give the mean f-values for the selected OARs for the main and regional plans. The last two columns describe the difference in f-value and OAR dosimetric endpoints (maximum dose for spinal cord and mean dose for other OARs) between ten replan and clinical cases.

OAR	*f-value* (mean ±1SD) for 109 plans		Replan vs. Clinical (10 cases) Δ = (clinical value – replan value)	
	Main	Region	Δ*f*(mean ±1SD)	ΔD(mean ±1SD)
Spinal Cord	0.25±0.11	0.42±0.09	0.22±0.12	7.65±3.2
Left Parotid	0.20±0.11	0.19±0.14	0.06±0.10	1.41±3.0
Right Parotid	0.22±0.10	0.16±0.11	0.05±0.07	1.48±3.0
Larynx	0.27±0.13	0.35±0.17	0.20±0.13	8.43±4.0
Supraglottis	0.27±0.14	0.35±0.16	0.10±0.10	5.73±4.3
OARPharynx	0.35±0.14	0.41±0.11	0.01±0.08	2.48±2.8
Trachea	0.26±0.13	0.32±0.14	0.17±0.09	5.82±4.6
Esophagus	0.17±0.11	0.32±0.13	0.16±0.12	5.33±5.2
Oral Cavity	0.39±0.09	0.35±0.12	-0.01±0.08	-0.58±2.1

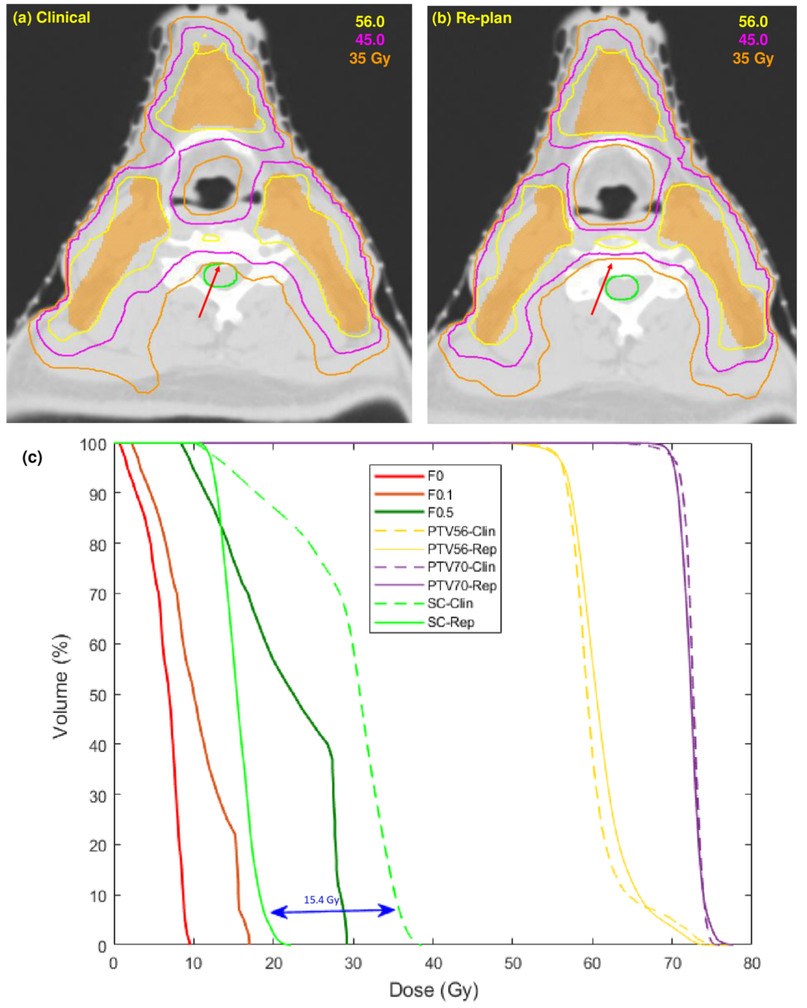

Figure 1: Comparison of the spinal cord dose between the clinical (a) and f-DVH guided replan (b) nesopharynx case. Spinal cord is shown in green countour. The red arrows show the sparing of spinal cord. The DVH comparison of spinal cord and targets (PTV70 and PTV56) is presented in figure (c). The feasibility DVHs are also shown for the comparison.

CONCLUSIONS

- Feasibility DVH could be used to assess the plan quality regarding the OAR sparing and could serve as guidance for reducing the plan quality variability for HN treatments.
- It was observed that the *f*-DVH guided optimization could lead to considerable sparing to the OARs situated medially - spinal cord, larynx, supraglottis, trachea and esophagus. No considerable increase in the dose to other OARs was observed.
- The re-planned cases showed decrease in the *f*-value from the clinical plans resulting in the decrease in the dose to OARs.
- Feasibility guided auto-planning was found to be a suitable tool for HN treatment plan optimization resulting in clinically acceptable plan quality within the allotted treatment planning time for such cases.

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