INTRODUCTION

- The need to transfer IMRT or VMAT plans to a different machine can happen due to machine downtime, especially for time-sensitive cancers (e.g., head/neck).
- In a multi-vendor clinic, this may require transfer to a different linac type.
- Given the short amount of time available for the re-plan in this situation, the quality of the plan optimization may be compromised.
- This project studies the quality of H&N VMAT re-plans when a different type of linac must be used for the new plan.

AIM

- To evaluate the quality of H&N VMAT treatment plans originally optimized for one machine and converted to a different machine.
- To understand the plan quality differences in order to improve plan transfer and re-optimization methods.

METHODS

PATIENT MATERIAL:

- 10 H&N VMAT plans from two planners with different optimization styles (5 per planner).

TREATMENT PLAN DETAILS:

- Treatment type: Simultaneous integrated boost (SIB), a sample dose distribution is shown in Fig. 1
- Prescription dose: 66-70 Gy to high-risk, 54-60 Gy to intermediate-risk, and 50-54 Gy to low-risk target volume
- TPS: Eclipse
- Linac M1: Varian TrueBeam, 120-leaf MLC (central leaves 0.5 cm, outer leaves 1.0 cm)
- Linac M2: Elekta Versa HD, 160-leaf MLC (all leaves 0.5 cm)
- Plan Technique: VMAT, 3-4 Arcs with different collimator angles, 6MV

STUDY DESIGN:

- To decompose various interplaying effects (changing machines, restarting optimization, different optimization strategies), different treatment plans and analyses were used (Table 1 and Figure 2)
- A comparison was performed in terms of percentage differences in the OAR dose metrics between the original plan and different re-plans.
- All plans were normalized to the clinical plan target coverage to prevent normalization differences from overriding other effects.

METHODS (cont)

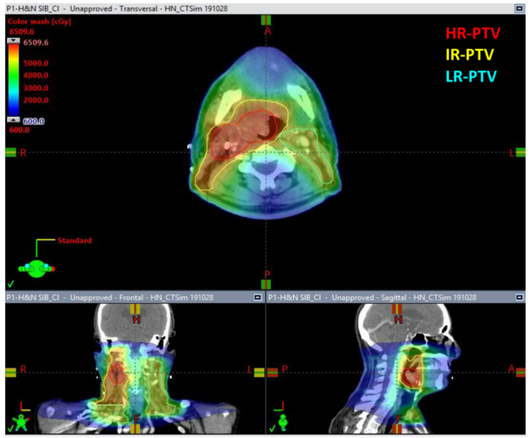

Figure 1. An example dose distribution for a SIB H&N treatment plan, showing high-risk (HR-PTV), intermediate-risk (IR-PTV) and low-risk (LR-PTV) PTV contours.

Table 1. Three plans are compared for each patient: the original clinical plan (P-Clin) and plans run based on the final clinical objectives using the original machine M1 (P-M1) and the new machine M2 (P-M2)

Individual Plans	
P-Clin	Original clinical plan on machine M1
P-M1	• Same beam arrangement as P-Clin • Single run of the optimization using the final set of objectives from P-Clin • Normalized to the same (high-risk) target coverage as P-Clin
P-M2	• Same beam arrangement as P-Clin, except machine changed to M2 • Single run of the optimization using the final set of objectives from P-Clin • Normalized to the same (high-risk) target coverage as P-Clin
Treatment Course Cumulative Plans	
P-Clin-Course	Cumulation of P-Clin over all treatment fractions (30,33, or 35 fractions, depending on plan prescription)
P-1FxM2-Course	Plan Sum of P-M2 x1 fx and P-Clin x(total-1) fx

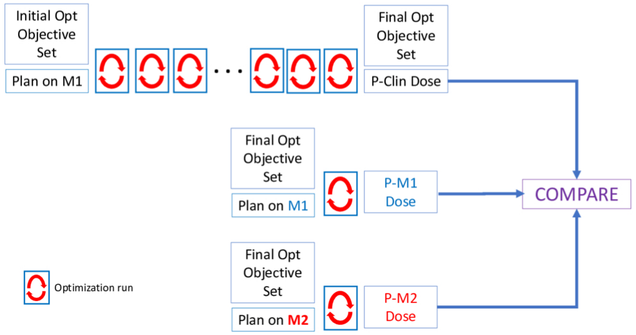

Figure 2. *The optimization processes used to create the different plans in the study* ***Dose (P-M2) – Dose (P-Clin)*** *comparison evaluates the OAR and target metric differences when the plan is moved to M2 and a single optimization is run, based on the final clinical plan objective function.* ***Dose (P-M2) – Dose (P-M1)*** *comparison evaluates the OAR and target metric differences due to a single optimization run based on the final clinical plan objective function for M1, to document the effect of doing a single optimization run based on the final optimization objectives for the same machine and plan.*

RESULTS

INDIVIDUAL PLANS COMPARISON:

- Large differences in OAR metrics were found in the M2 plans compared to the original clinical plans (P-Clin): up to +154% for parotid
- Mean increase in OAR metrics was +19% (±32%) across all OARs for all cases. (Fig. 3a).
- The mean difference between the two re-optimized plans, P-M2 and P-M1, was only -1% (±32%), (Fig. 3b).
- Therefore, the bulk of the OAR dosimetric differences in the transferred plans appears to be due to re-optimization rather than machine differences.
- Figure 4 shows the % dose differences for high, intermediate and low-risk PTV volumes in P-M2 versus P-Clin, and P-M2 versus P-M1.
- These results also show that most dosimetric differences are due to re-optimization, rather than machine type.

CUMULATIVE PLANS COMPARISON:

- Differences over a whole course are shown in Fig. 5. The average of the absolute percentage differences was 0.8% (± 1.1%) and the three largest percentage differences were 4.5%, 3.2% and 3.0% for parotids, brachial plexus and spinal cord, respectively.
- The plan quality difference as a result of restarting the optimization was found to be significantly dependent on the planner's optimization method, and this will be evaluated in more detail in further work.

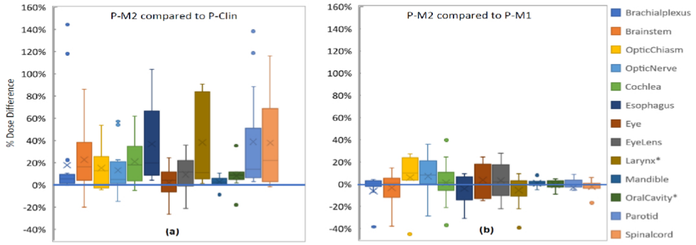

Figure 3. *Box plots for OAR dose metric differences ($D_{0.03cc}$ or mean dose (asterix)) for 1 fraction for all ten H&N SIB treatment plans.*
(a) P-M2 vs P-Clin $[(D_{P\text{-}M2} - D_{P\text{-}Clin})/D_{P\text{-}Clin}\ \%]$ (b) P-M2 vs P-M1 $[(D_{P\text{-}M2} - D_{P\text{-}M1})/D_{P\text{-}M1}\ \%]$

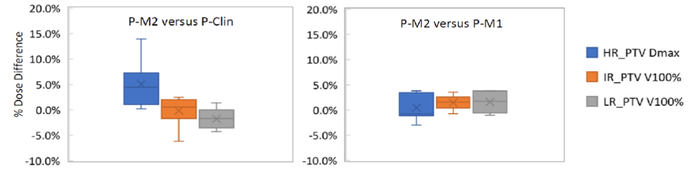

Figure 4. *Percentage dose differences for high-risk PTV D_{max}, intermediate-risk PTV $V_{100\%}$ and low-risk PTV $V_{100\%}$ for P-M2 vs P-Clin and P-M2 vs P-M1.*

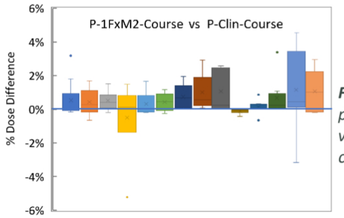

Figure 5. *The increase (percentage) in OAR dose parameters for an entire course for P-Clin-Course vs P-1FxM2-Course (the difference for a whole course due to 1 fraction of P-M2).*

CONCLUSIONS

- Transfer of complicated H&N plans to another linac type without appropriate re-optimization can result in significant degradation of plan quality (e.g. OAR dose).
- Clustering of the differences in OAR and target metrics between P-M1 and P-M2 near zero shows there is no systematic difference in plan quality between the two machines.
- Therefore, virtually all the observed degradation stems from restarting the optimization rather than different MLC designs or other machine differences.
- Initial evaluation of differences in the re-optimized transferred H&N plans from 2 different planners with different optimization styles accentuates the importance of standardization of optimization methods. A detailed comparison and analysis of these optimization differences will be pursued in future work.
- The evaluation of overall course dosimetric differences due to one fraction of the degraded plans shows that in some cases and for some OARs, the differences may be large enough to require detailed clinical evaluation to decide if they are acceptable.
- Further study of this issue is also warranted as part of our plan to minimize the potential disruptions to treatment of our head/neck patients due to a down-machine.

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