NoPAUSE: A blinded, multiple-observer analysis of clinical acceptability and preference for automated VMAT plan optimization

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ABSTRACT

Purpose: Previous work has demonstrated that automatically optimized plans were dosimetrically non-inferior to manual, interactively optimized plans based on institutional clinical goals in a retrospective paired analysis. This study aimed to extend this work to clinical acceptability and physician preference based on expert review.

Methods: An in-house treatment planning automation system (TPAS) was used to retrospectively generate treatment plans for 48 cases. Two radiation oncologists (ROs), one from outside our institution, compared the TPAS and manual plan and were asked to (a) score each plan on a 1-5 (5=ideal) Likert scale of clinical acceptability, (b) indicate which plan they preferred, and (c) indicate the strength of their preference on a scale of 1-3 (3=strong preference). Both ROs (referenced as "AY" and "MC") were blinded to which plan was created by TPAS, as well as each other's responses. Scores were analyzed using summary statistics and paired t-testing to determine if significant differences (p<0.05) were present.

Results: The mean clinical acceptability score for the manual plans was 4.5 (AY) and 4.1 (MC), compared to 4.7 (AY) and 4.2 (MC) for the TPAS plans, a difference which was significant for both. TPAS plans were preferred in 70.8% (AY) and 65% (MC) of cases with a significantly higher average preference of 2.1 (AY) and 1.9 (MC) vs 1.6 (AY) and 1.2 (MC) for the manual plans.

Conclusion: Plans generated by TPAS were often preferred to their historical controls, the latter of which are already highly selected for quality. These results support greater integration of automatic planning into clinical planning workflows.

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INTRODUCTION

The Northern Plan Automation Services (NoPAUSE) project is a collection of open-source automation apps and scripts that aim to improve clinical efficiency. A key component is TPAS, our treatment planning automation system for Eclipse.

TPAS orchestrates "one-click" automatic VMAT planning based on user-defined protocols. These protocols specify permissible field geometries, isocentre-placement rules, clinical objectives and optimization structure definitions (Fig. 1). Objectives can be set by reference to an Eclipse template, automatically using gradient fall-off models, or by RapidPlan if a model exists. Clinical goals have an assigned importance within each protocol, and TPAS iterates to achieve them.

Users submit a request within Eclipse, in which structure mappings and patient-specific planning directives like bolus and flash are confirmed. The request is then distributed to an available TPAS service. Progress can be monitored via a browser dashboard (Fig. 2) and email reports configured to update the user on completion.

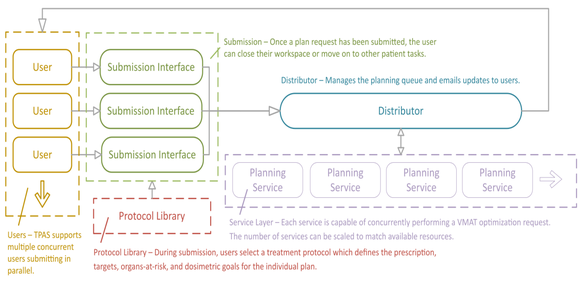

Figure 1. TPAS Architecture

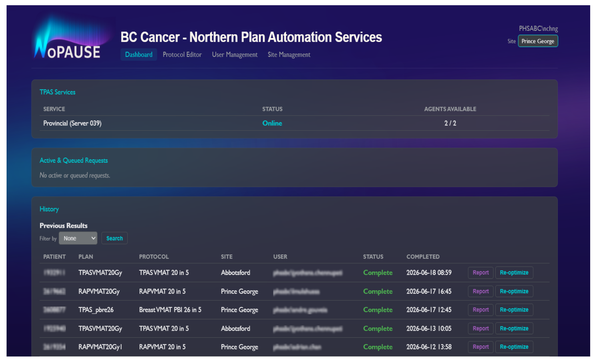

Figure 2. TPAS Dashboard

Our research is motivated by the considerable efficiency gains that may be possible if physicians can contour and approve a plan in one encounter. This workflow is well-established within BC for rapid-palliative workflows (same-day VMAT), but there is increasing interest in extending this to more complex curative techniques, including partial breast, prostate, and spine/liver SABR.

Previous work was promising, finding that TPAS-generated plans were non-inferior to manual ones for H&N, prostate and rectal cancer sites based on institutional DVH-based clinical goal comparisons[1,2]. However, **because features salient to clinical preference may be lost in DVH projection**, this study aimed to investigate how TPAS plans compared to manual controls in a blinded review simulating a real plan assessment workflow.

METHODS AND MATERIALS

TPAS was used to retrospectively replan N=48 clinical H&N plans with approval from our institutional REB based on institutional clinical goals (Table 1). A locally trained RapidPlan model was used in both arms of this study, with default objectives adjusted as needed. No post-hoc manual adjustments were made in the TPAS arm.

Both arms were re-calculated on identical structure sets and stripped of any identifying metadata. Plans for each case were randomly assigned label "A" or "B". Two radiation oncologists, one external to the institution, were asked to score them for both clinical acceptability and strength of preference according to the Likert scale in Figure 3. Both were also blinded to the other's responses.

Clinical acceptability scale

1 = Not clinically acceptable and exceptionally poor relative to normal planning expectations.
2 = Not clinically acceptable but may be with significant revisions to multiple or critical structures.
3 = Potentially clinically acceptable, although minor changes are necessary and would be requested in a clinical setting.
4 = Clinically acceptable to treat. Although there may be potential improvements, it is unclear if they are achievable and are not concerning enough that a revision would be requested in a clinical setting.
5 = Clinically acceptable to treat. The plan is high quality relative to normal planning expectations.

Strength of preference scale

1 = No, or very slight preference; plans are very similar or demonstrate trade-offs for which I have clinical equipoise.
2 = Weak preference; I prefer the plan, but I would not be surprised if colleagues disagreed.
3 = Strong preference; I prefer the plan and feel reasonably confident that colleagues would agree.

Figure 3. Likert scales for clinical acceptability and preference

Responses were analyzed for differences in median clinical acceptability and for non-inferiority using Wilcoxon signed-rank tests with a p-value threshold of 0.05. Agreement between observers ("AY" and "MC") was assessed using Cohen's weighted kappa and descriptive statistics.

Structure	Clinical Goal
Brainstem_PRV	D0.035cc < 54 Gy
SpinalCord_PRV	D0.035cc < 54 Gy
SpinalCord	D0.035cc < 48 Gy
PTV_High	V95% High Rx > 98%
	Max dose< 110% High Rx
CTV_High	Min dose > 95% High Rx
	V99% High Rx > 94%
PTV_Int	V95% Int Rx > 98%
	Max dose < 105% High Rx
PTV_Low	V95% of Low Rx > 98%
	Max dose < 105% High Rx
Brain	D0.035cc < 60 Gy
Optics_PRV	D0.035cc < 54 Gy
Eye_L	D0.035cc < 45 Gy
Eye_R	D0.035cc < 45 Gy
Lens_L	D0.035cc < 10 Gy
Lens_R	D0.035cc < 10 Gy
Parotid_R	Mean dose < 20 Gy [26 accept]
Parotid_L	Mean dose < 20 Gy [26 accept]
Submand_R	Mean dose < 20 Gy [26 accept]
Submand_L	Mean dose < 20 Gy [26 accept]
Larynx	Mean dose < 45 Gy
Musc_Cons	Mean dose < 55 Gy
OralCavity	Mean dose < 50 Gy
Mandible	V50 Gy < 30%
	V70 Gy < 1%

Table 1. Reference clinical goals for plans in this study

RESULTS AND DISCUSSION

Both observers found all plans to be clinically acceptable with at least a score of 3. All TPAS plans had at least a score of 4, compared to 93.8% of manual plans.

The mean TPAS (vs Manual) **clinical acceptability** scores for AY and MC were 4.7 (4.5) and 4.2 (4.1) respectively. The difference in medians was statistically significant by Wilcoxon signed-rank test for AY only.

TPAS plans were found to be non-inferior in 95.8% (AY) and 97.9% (MC) of cases (p<0.001). Both observers concurred that TPAS was non-inferior in 93.7% of cases, corresponding to a Cohen's weighted kappa of 0.46. Adjusting for prevalence toward 4-5 scores the metric rises to 0.88.

In cases where TPAS (vs Manual) was preferred, the **strength of preference** was significantly higher - on average 2.1 (1.6) and 1.9 (1.2) for AY and MC respectively

Automatic planning for H&N is well studied and is increasingly supported by vendors either through specific modules or scripting capabilities[3,4]. **The clinical acceptability rates seen here compare favorably with benchmark studies[5,6]**. A strength of the present work is that clinical expectations and tools like RapidPlan (independently shown to improve quality) are well controlled between arms. This helped to isolate the impact of automating the challenging "last mile" of subtle adjustments than can often distinguish a good treatment plan from an excellent one. Weaknesses include a small number of observers, and our single institution scope.

CONCLUSIONS

TPAS plans for H&N in this cohort were all clinically acceptable, and more likely to be strongly preferred to the original delivered plan in a clinically realistic plan review process. These results support offering physician-initiated TPAS for H&N planning. Similar validations for other sites are ongoing.

Please see our other work at AAPM/COMP: SU-315-GPT-T-224, WE-240-220-3, SU-315-GPD-T-1011

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