Impact of Widespread Automated Planning Implementation: Longitudinal Study of Durability of Quality Improvements and Workforce Efficiency Gains

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RETHINKING MEDICAL PHYSICS

INTRODUCTION

As automated planning systems become more broadly available, the most important questions of their impact center on resultant plan quality and efficiency gains. The purpose of this work was to assess the impact on workforce efficiency and plan quality variability as we implemented knowledge-based automated planning (KBP) across multiple disease sites and several hundred patients over three years.

AIM

- Evaluate plan variability in several disease sites across several stages of automated planning
- Assess the effect of automated planning on the workflow efficiency

METHODS

The effects of KBP implementation were investigated across 5 disease sites (Table 1) in 3 sequential phases:

- "Human only": manual planning just prior to KBP implementation. Retrospectively re-planned with KBP to assess pre-autoplanning variability.
- "Human/KBP": Both manual and KBP plans were generated, treatment plan chosen by physician
- "KBP+Human": KBP plans generated for each case and manually-refined at planner discretion.

To assess changes in plan variability, we determined site-specific DVH parameters comparing OAR values for clinical and KBP plans: ΔDx=Dx,clinical-Dx,KBP

Significance tested between "Human only" and "KBP+Human" with unpaired 2-sided t-tests ($p<0.001$).

Workflow efficiency was quantified by plans/dosimetrist/day.

RESULTS – PLAN VARIABILITY

Disease site	Human	Human/KBP	KBP+Human
Prostate	53	41	218
Prostatic fossa	24	32	45
Left Lung SBRT	27	17	43
Right Lung SBRT	27	19	57
Head-and-neck	52	36	141

Table 1: Number of patient plans investigated by disease site and group.

Prostate	Human only	KBP+Human
Bladder ΔV40Gy	2.4%±2.5%	-0.4%±2.2%
Penile Bulb ΔDmean	7.8%±7.6%	1.1%±3.8%
Rectum ΔV40Gy	5.6%±5.2%	-0.7±2.9%
Rectum ΔV65Gy	1.5%±1.8%	-0.2%±1.3%
Rectum ΔV75Gy	1.0%±1.0%	-0.1%±1.0%
Prostatic fossa	**Human only**	**KBP+Human**
Bladder ΔV40Gy	2.9%±3.3%	-0.3%±2.1%
Penile Bulb ΔDmean	11.1%±6.1%	2.6%±5.6%
Rectum ΔV40Gy	3.3%±2.8%	0.1%±3.9%
Rectum ΔV65Gy	1.8%±1.7%	0.0%±1.9%
Rectum ΔV70.2Gy	3.3%±2.1%	-0.2%±1.6%
Left Lung SBRT	**Human only**	**KBP+Human**
No significant changes		
Right Lung SBRT		
No significant changes		
Head-and-neck	**Human only**	**KBP+Human**
Parotid Right ΔDmean	4.5Gy±5.7Gy	-0.2Gy±3.4Gy
Cricopharyngeus ΔDmean	15.0Gy±8.0Gy	0.4Gy±3.5Gy
Parotid Left ΔDmean	3.5Gy±4.0Gy	-0.1Gy±2.8Gy
Esophagus ΔDmean	4.2Gy±4.2Gy	0.2Gy±1.9Gy
Larynx ΔDmean	5.8Gy±5.9Gy	0.3Gy±2.0Gy
Cochlea Left ΔDmean	6.0Gy±7.8Gy	0.0Gy±2.2Gy

Table 2: DVH parameters that were significantly ($p<0.001$) changed between "Human only" and "KBP+Human" groups. Table displays mean and standard deviation of ΔDx.

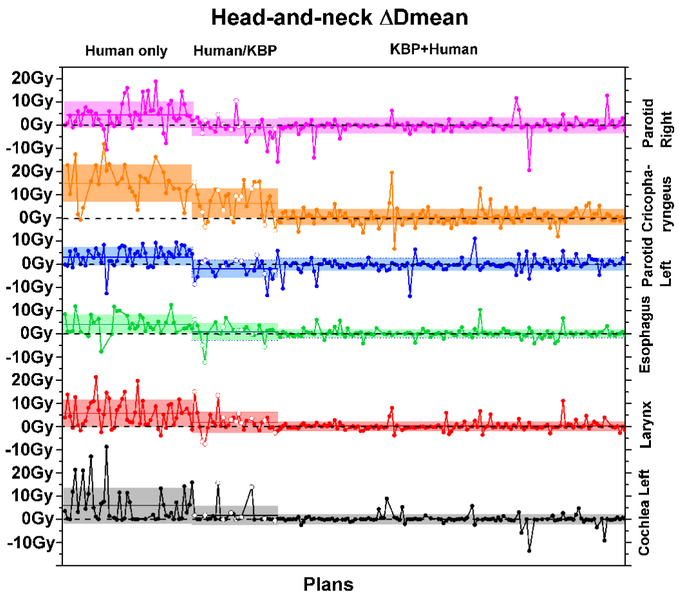

Fig 1: Plan variability in head-and-neck patients measured by dosimetric parameters. Plot displays the difference of the clinical plan used to treat the patient and a KBP plan. This approach controls for the influence of individual patient anatomy on dosimetric results.
The colored bands represent the average value and standard deviation in each group, representing quantitative measures of plan quality and variability. The Human/KBP group was treated with either a KBP plan (open circles) or a human plan (solid circles), either plan was re-planned with an independent KBP routine to assess plan variability.

RESULTS – WORKFLOW EFFICIENCY

Planner productivity increased 8.6%/year with the introduction of KBP (0.94→1.20 plans/dosimetrist/day) over the course of the study. The planner cohort remained mostly constant over the course of the study, and there were no known confounding variables influencing this result.

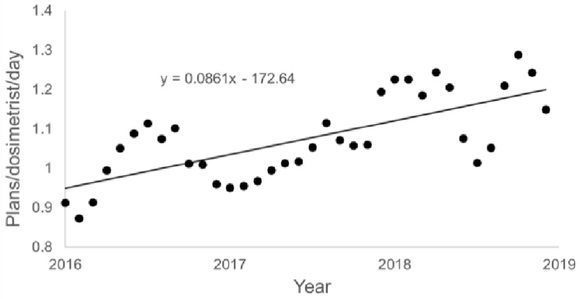

Fig 2: Average plans/dosimetrist/day for each month over the course of the study.

CONCLUSIONS

KBP adoption reduced planning variability across multiple disease sites concurrent to substantially increased efficiency of planners.

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