

Clinical Commissioning and Implementation of An In-House Artificial Intelligence (AI) Tool for Automatic Head-And-Neck Intensity Modulated Radiation Therapy (IMRT) Treatment Planning

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INTRODUCTION

With recent advancements in deep learning (DL), many techniques have been developed to automate time-consuming clinical tasks. However, translating/deploying these techniques into clinical applications requires thorough validation and quality assurance. This study describes the commissioning procedure for an in-house Artificial Intelligence (AI) tool for automatic Head and Neck (HN) Intensity Modulated Radiation Therapy (IMRT) planning for primary targets in our clinic. This AI tool demonstrated robust plan quality and excellent efficiency in the research environment. To be deployed in clinic, the original algorithms in the AI tool were wrapped in a graphical user interface (GUI) that interfaces with a commercial treatment planning system (TPS) in the clinical environment. The AI tool's workflow and performance were evaluated and validated by physicians and physicists specialized in HN treatment.

TABLES & FIGURES

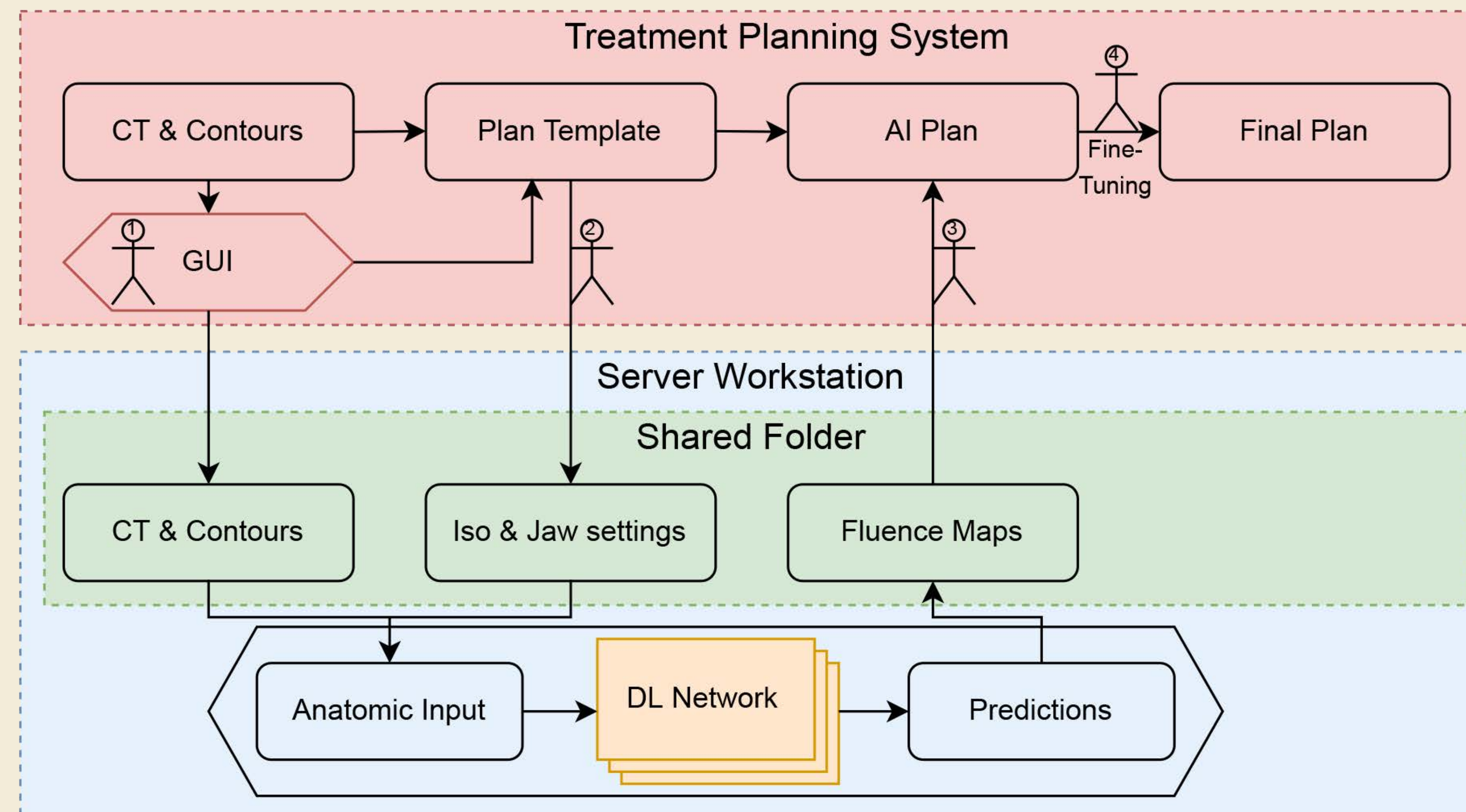


Figure 1. Planning workflow with the AI tool.

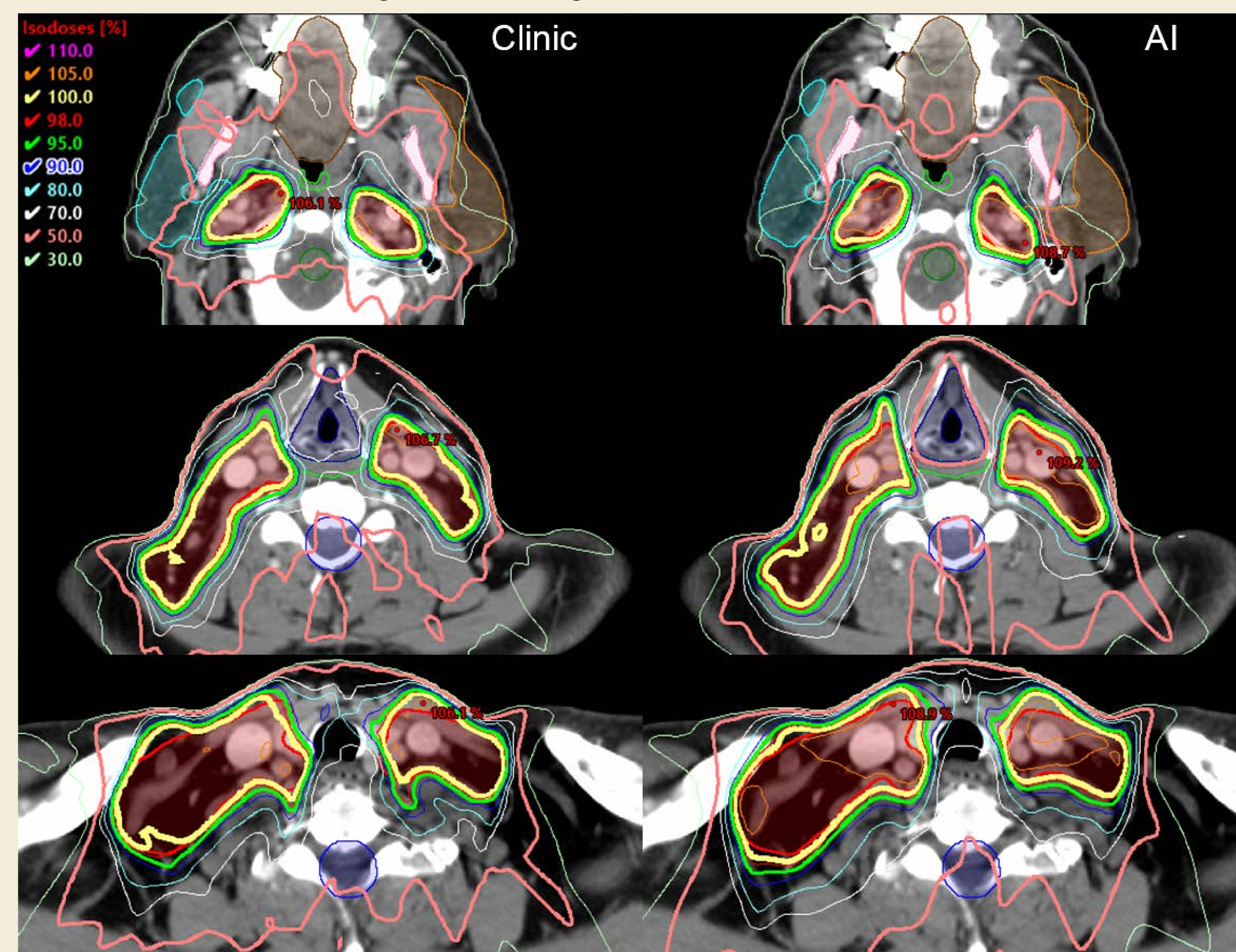


Figure 2. Dose distribution comparison of a commission case in axial view. Red: PTV44; cyan: right parotid; orange: left parotid; green: brainstem; blue: cord+5mm; dark blue: larynx; green: pharynx; brown: oral cavity.

Table 1. Prescription dose, delivery technique, and diagnosis of the 28 commissioning cases.

Prescription Dose	# of cases
44 Gy	24
50 Gy	4
Delivery technique	# of cases
9b IMRT	20
11b IMRT	6
3arc VMAT	1
4arc VMAT	1
Tumor site	# of cases
Nasopharynx	6
Oropharynx	2
Tonsil	5
Larynx	6
Base of tongue	8
Oral Cavity	1

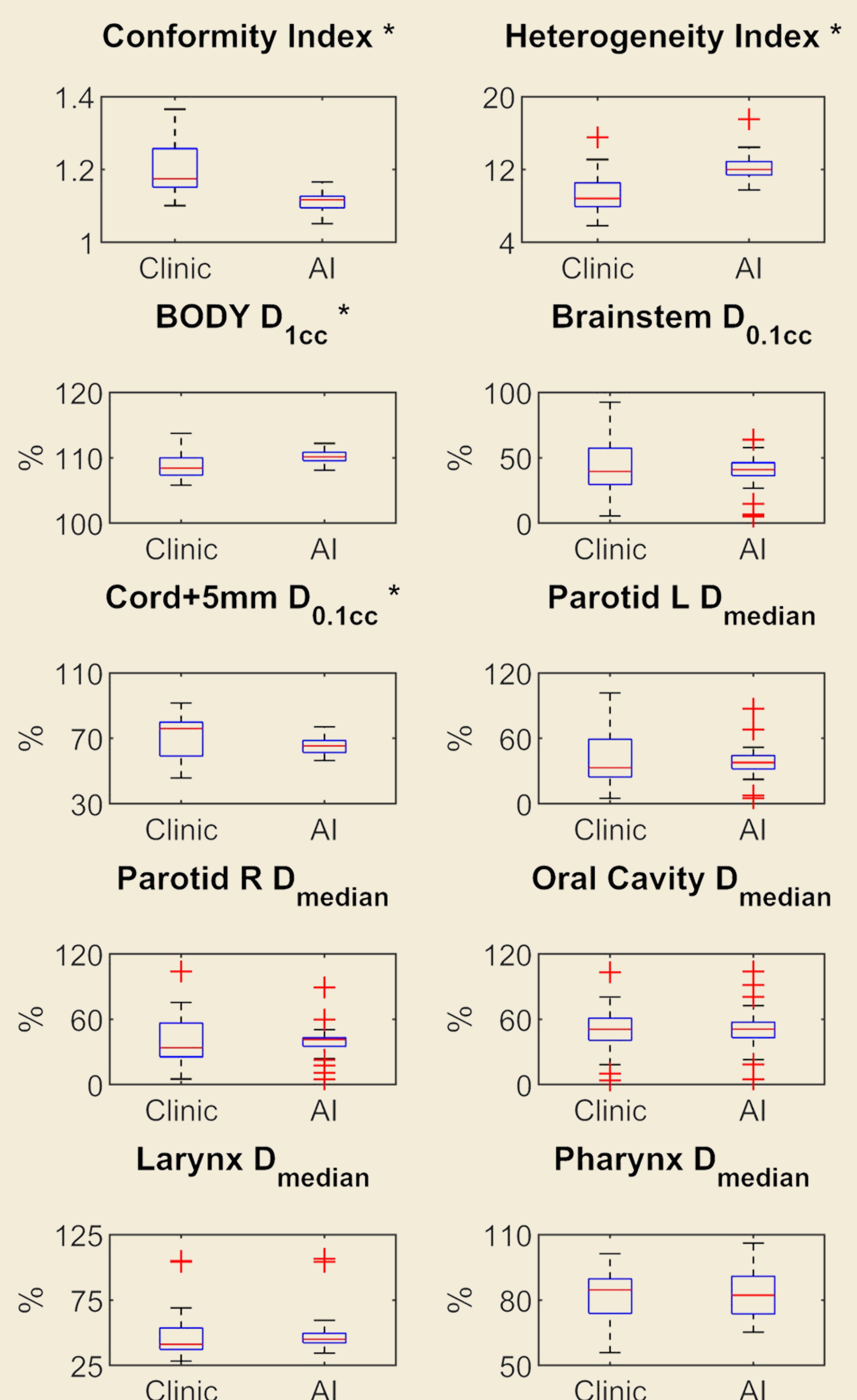


Figure 3. Boxplots of dosimetric endpoints of the 28 commissioning cases. * indicates statistical significance.

MATERIALS & METHODS

a) Patient data: 231 HN cases were included for the training/validation/testing of the DL network of the AI tool. 28 new cases were used for commissioning. Their tumor sites, prescription doses, and delivery techniques are listed in Table 1.

b) Workflow for generating a new AI plan: As in Figure 1:

- Actor symbol 1: human planners check the contours. The CT images and contours are exported to an intranet drive, and a template plan is automatically generated.
- Actor symbol 2: human planners review the isocenter position and jaw settings. The program on the server workstation then generates anatomic inputs from the CT images, contours, isocenter, and jaw settings. The DL network makes predictions based on the anatomic inputs.
- Actor symbol 3: human planners import the fluence maps into the TPS.
- Actor symbol 4 stands for fine-tuning and checking. Automated fine-tuning is provided, while manual fine-tuning is also available.

c) Evaluation: All plans were normalized so that 44 Gy covers 95% of PTV. Statistics were analyzed using Wilcoxon signed-rank tests with a significance level of 0.05 using MATLAB.

RESULTS

a) Planning efficiency: Using the default settings, generating a new plan takes about 10~15 minutes, including manual operations and dose calculation.

b) Dosimetric endpoint statistics: As shown in Figure 3, compared with clinical plans, AI plans had a significantly better conformity, meanwhile worse heterogeneity and maximum dose. OAR performance was comparable except that cord+5mm has lower dose in AI plans. These differences are generally considered subtle in clinics. AI plans' MU was 1569.0±278.6 (mean±stdev), while in the 26 clinical IMRT plans, the MU was 2011.4±515.8 (normalized to 44Gy prescription dose), showing a clearer advantage of AI plan in treatment delivery efficiency.

c) 3D dose distribution evaluation: In Figure 2, the 3D dose distribution in a commissioning case was evaluated and compared between AI and corresponding clinical plan. In the AI plan, dose distribution showed satisfying conformity and dose fall-off from the target. The target dose heterogeneity was acceptable with the hot spots located within the target. The coverage was reasonable with occasional missing near the edge of the target. The OAR dose sparing was decent. Overall, this AI plan and the clinical plan's dose distribution shows similar characteristics.

CONCLUSIONS

The in-house AI IMRT treatment planning tool was commissioned for the primary HN plans in our clinic. The commissioning process demonstrates outstanding performance and robustness of the AI tool, and the established commissioning workflow provides sufficient validation for clinical use. This AI tool is expected to become available to our clinic in the near future.