Adaptive Treatment Replanning with a Commercial Field-In-Field Optimization Platform

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INTRODUCTION

Patient interfraction anatomical changes observed via daily imaging can warrant replanning of radiotherapy treatments. This may require a new simulation and patient-specific measurement QA, delaying treatment by multiple days. For some patients, this can result in further anatomical changes during the delay. This work presents a fast adaptive replanning strategy using a commercial 3D conformal radiotherapy (3DCRT) optimizer for patients presenting with interfraction anatomy changes.

AIM

Investigate the feasibility of a fast adaptive replanning workflow using a commercial 3DCRT optimizer to allow for the fast replanning of patient treatments.

METHOD

Three previously treatment clinical cases (one 3DCRT and two VMAT) were replanned using a field-in-field technique via EZFluence(Radformation, New York, NY), a commercial fluence-based FiF optimizer:

- A 3DCRT bladder treatment with large day-to-day target geometry variation
- A VMAT lung treatment with two target volumes which required additional planning target volume (PTV) expansions due to large day-to-day tumor motion variation observed in daily conebeam CTs.
- A thoracic multi-metastatic VMAT treatment with two targets, a right rib tumor and a right lung tumor, with a 12-cm separation between the targets.

Each scenario was replanned using corrected target contours and the time required to replan the treatment was recorded. The corresponding corrected target D95% was compared between the replan and original plan.

RESULTS

- The bladder treatment was replanned using a corrected target volume based on a daily CBCT. A new treatment plan resulted in a corrected PTV D95% improvement from 96.9% to 100.8%. A comparison of the two treatment plans is shown in **Figure 1**.
- The two lung PTVs were expanded based on the observed increased geometric uncertainties. A plan based on the corrections resulted in corrected PTV D95% improvements from 97.5% to 99.6% and 90.7% to 100.9%. The new treatment plans resulted in organ doses well below clinical limits. The improvement of corrected target coverage is shown for one of the PTVs in **Figure 2**.
- The multi-metastatic thoracic case was replanned and resulted in similar quality plans to the original VMAT plan, as shown in **Table 1**.
- The EZFluence-generated FiF plans generally resulted in less sparing of organs-at-risk (OAR) that were nearby or overlapped the PTVs than VMAT treatment plans.
- A potential adaptive replanning workflow with the estimated required time for each step of the process is shown in **Figure 3**. EZFluence allowed for the creation of a treatment plan in 11.2±4.2 minutes on average, enabling a feasible online adaptation when paired with an abbreviated approval and physics check workflow.

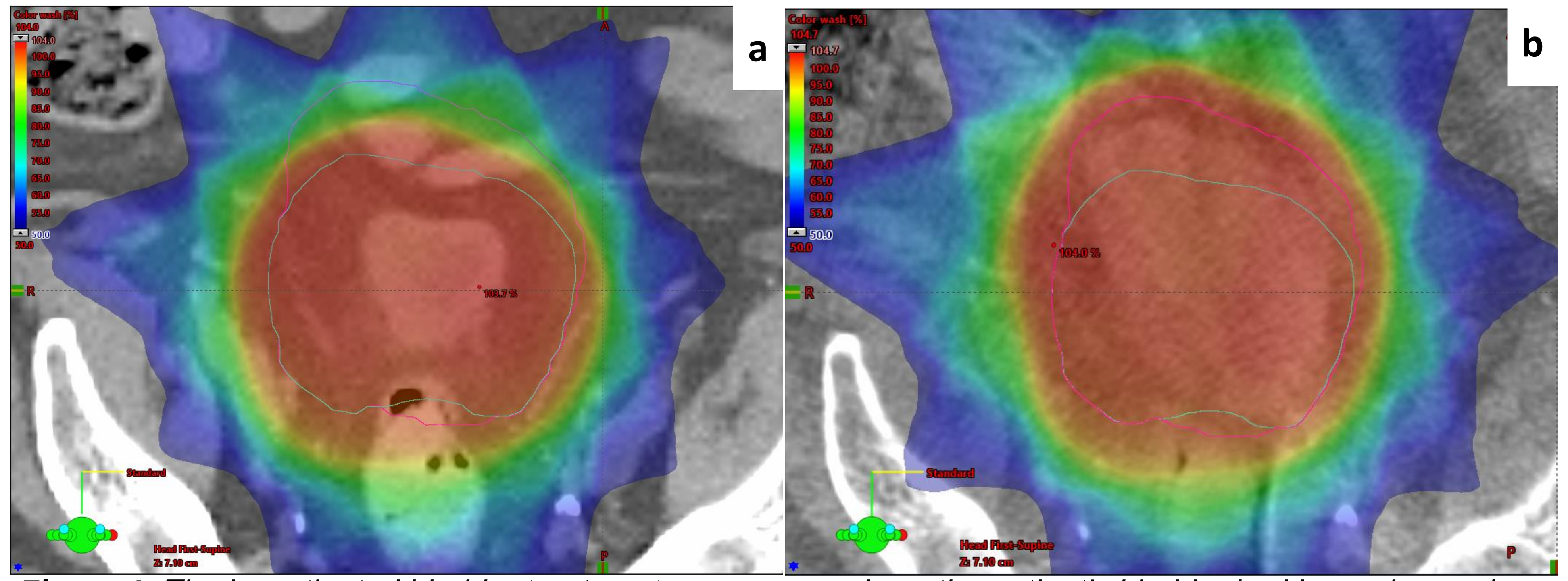

Figure 1: The investigated bladder treatment was a case where the patient's bladder had large day-to-day variation. A new target was contoured based on the patient's daily CBCT (magenta contour). The initial 7-beam FiF treatment plan targeted the original PTV (cyan contour), undercovering the corrected PTV (a). The treatment was replanned on the planning CT to improve coverage to the CBCT-based corrected PTV (b). The dose distribution is displayed on the CBCT to highlight the bladder variation.

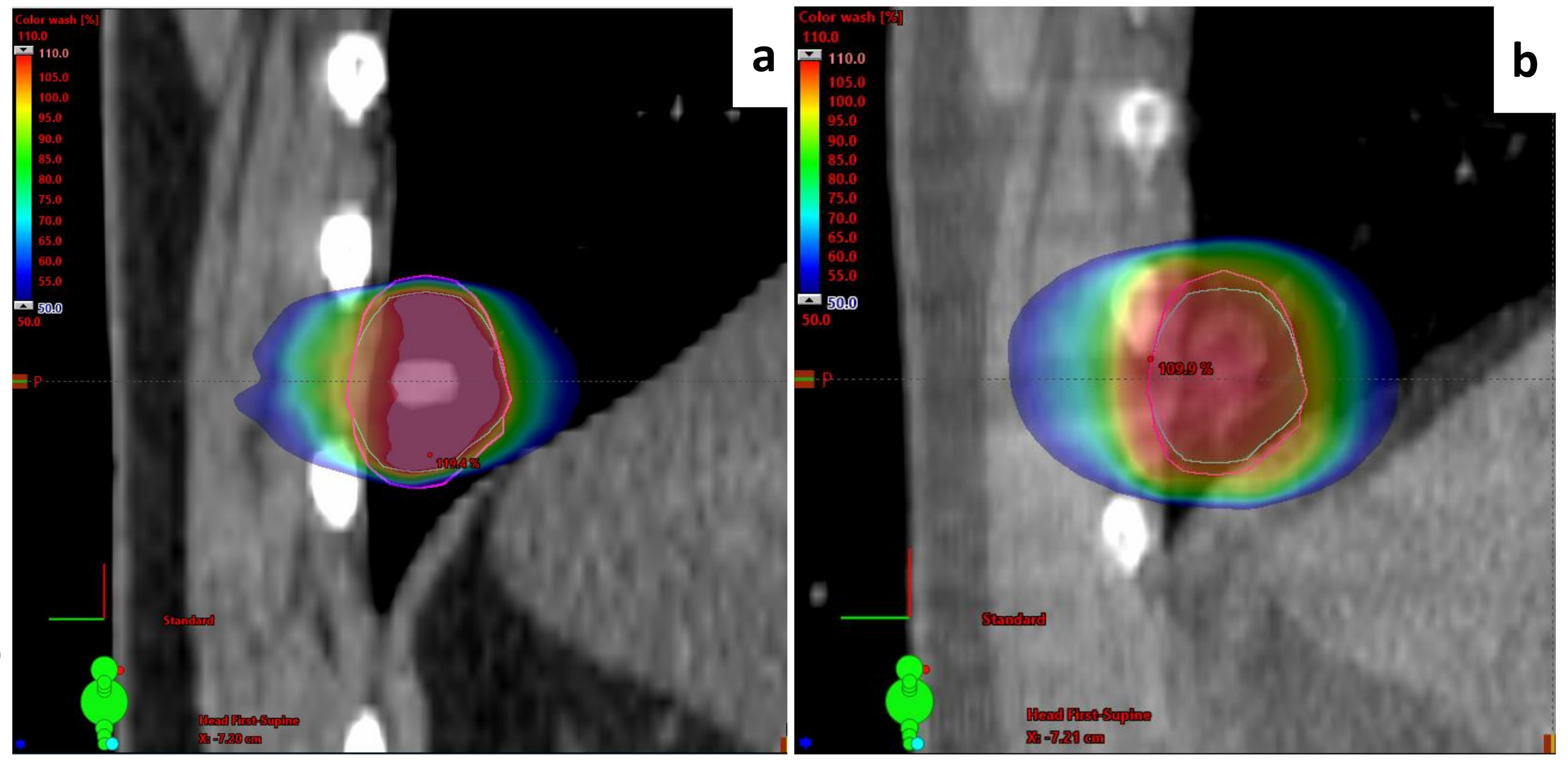

Figure 2: The original lung VMAT plan for one of the targets (a) undercovered the corrected PTV, and a 7-beam FiF plan (b) was created with the EZFluence VMAT plan conversion tool. The original PTV is shown by the cyan contour while the corrected PTV is shown in magenta. The corrected plan was calculated on the planning CT but is displayed on a daily CBCT to highlight the tumor setup error. The new plan improved target coverage with an increase of lung-GTV V12.5Gy from 2.1% to 3.0% and an increase of heart D0.1cc from 1.75 Gy to 3.17 Gy, but all doses met priority 1 clinical limits.

Table 1: The multi-metastatic thoracic treatment was a patient who had two PTVs: one in the right rib and the second in the right lung. The VMAT plans were replanned as 7-beam and 9-beam FiF plans, respectively, using the VMAT plan conversion tool. The FiF plans resulted in sufficient PTV coverage but had higher OAR doses than those of the VMAT plans.

Treatment Plan	PTV D95% (%)	Heart D0.1 cc (Gy)	Lungs-CTV V12.5 Gy (%)
VMAT Rib	100.7	16.73	4.5
FiF Rib	100.3	20.94	5.5
VMAT Lung	103.7	1.19	1.5
FiF Lung	100.2	2.99	2.2

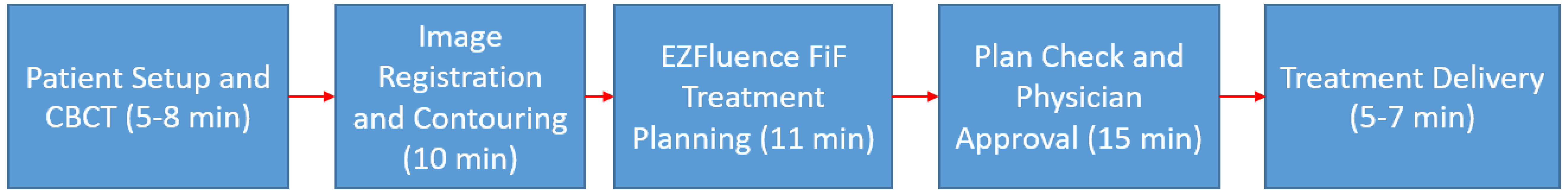

Figure 3: An example workflow diagram displaying how FiF replanning with a commercial fluence-based optimizer could be incorporated into clinical workflow. This process includes an abridged plan check. If a patient CBCT is used for contouring, the total appointment could be kept under an hour.

CONCLUSIONS

EZFluence showed potential for fast and efficient adaptive replanning for cases that exhibit interfraction geometric changes that compromise treatment quality. Further work is required to test more scenarios and to optimize overlapping OAR sparing in plans delivered by FiF versus VMAT. This method could provide a useful clinical tool with minimal alterations to workflow and equipment for unique patient cases that require fast replanning due to relatively rapid interfraction anatomical changes.

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REFERENCES

EZFluence 2.0 Quick Start Guide. Rev 3.0. Radformation. New York, New York, USA.

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