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EASTERN TIME [GMT-4]

Enabling Jaw tracking in monitoring of prostate motion using on board MVKV imaging system.

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INTRODUCTION

In this study, we investigate the feasibility of updating our in-house MLC_MODIFIER [1], program to account for Jaw tracking. Our MV/kV on-treatment imaging paradigm [2] is dependent on the ability to visualize the fiducial markers on the MV image. We have created an eclipse script, MLC_MODIFIER, which inserts imaging control points into the VMAT beam. The MLC_MODIFIER program will open the MLC aperture at these imaging control points to expose one fiducial marker. With the implementation of jaw tracking, we adapted MLC_MODIFIER to handle changes in jaw position between control points and to modify jaw positions in addition to MLC positions as need to expose fiducials.

AIM

The aim of this study is to evaluate clinical feasibility adapting the MLC_MOD program to plans with Jaw Tracking features. We evaluated the frequency and magnitude of jaw changes and the dosimetric impact of these changes.

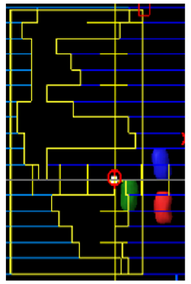
METHOD

An internal program, MLC_MODIFIER is used clinically to modify MLC patterns and ensure visibility of fiducials during treatment for MV/kV tracking. At control points where kV images are acquired, every 20 degrees, imaging control points are inserted into the VMAT beam, and MLC positions are modified so at least one implanted fiducial is visible on the MV image. The MLC_MODIFIER program was updated in preparation of the implementation of jaw tracking, which is a commercial feature available on some linacs that permit dynamic jaw position to track MLC location during VMAT and IMRT delivery. The new version of MLC_MODIFIER must be able handle different jaw positions as a function of control point, in the previous version the jaw positions were the same for all control points. In addition, A consequence of jaw tracking, markers can be blocked by variable jaws, therefore MLC_MODIFIER must now modify both the MLC and the jaw positions if necessary, to expose the fiducial marker on the MV image. The new MLC_MODIFIER program reads the jaw positions for each control point and for imaging control points modifies it to expose one fiducial. To assess feasibility, 5 patients were retrospectively re-planned with jaw tracking (Jaw_plan) and the new version of MLC_MODIFIER was run to create plans (MV_plans) with MV imaging capabilities. The following parameters were evaluated: trigger point values, jaw position changes (frequency and magnitude), dosimetric consequences and changes in MU.

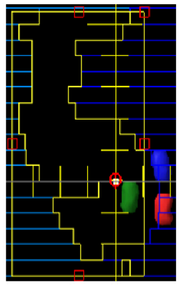
EXAMPLE

The new version of MLC_MODIFIER reads in the jaw positions for each control point and modify them if necessary, at the inserted imaging control points, so to expose one fiducial for 1cm margin. Figure 1 shows an example of this. 1a shows the planning system optimized MLC positions and all the fiducials are blocked by the MLC and jaws. 1b shows the old MLC_MODIFIER inserted imaging control point where the MLC are opened to expose the green fiducial, but because of the jaw position there is not enough margin to permit on-tx monitoring. 1c shows the same control point where both the MLC apertures and jaws are modified.

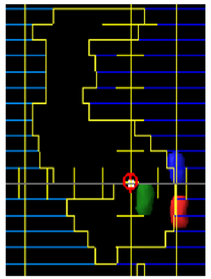
1a. Original jaw tracking plan



1b. Modified control point with old MLC_MODIFIER. X2 jaw was too tight on the green fiducial.



1c. New MLC MODIFIER adjusted the jaw so green fiducial is now exposed with 1 CM margin.



RESULTS

We retrospectively re-planned 5 patients with jaw tracking (Jaw_plan) and prepared the plans for MV/kV imaging by running the new version of MLC_MODIFIER (MV_plan). MLC_MODIFIER did insert the imaging control points at the correct trigger locations for all plans. We also found that MLC_MODIFIER program changed the jaw position on average 4% of the time. The jaw size defined by x times y, was greater for the MV_Plans 61 vs 58.9 cm^2 for MV_plans and Jaw_plans respectively.

When we evaluated the dosimetric differences between the Jaw_plan and the MV_plan, we did find that if we kept the MU the same, the PTV mean dose was on average 1.1% higher for the MV_plan. Once we renormalized by this amount, we found that all the critical structures still met our standard planning constraints. MU were lower with the MV_Plans by on average 1.2% due to the renormalization.

CONCLUSIONS

It is possible to modify both MLC pattern and jaw position to permit automatic on-treatment MV/kV detection and monitoring of fiducials with no impact on plan quality. The new version of MLC_MODIFIER is versatile and can handle plans with dynamic jaw and without. We released this software in the clinic beginning of May and successfully used the new version MLC_MODIFIER for 20 patients, 10 with dynamic jaws and 10 without.

REFERENCES

1. Happersett L, Wang P, Zhang P, Mechalakos J, Li G, Eley E, Zelefsky M, Mageras G, Damato AL, Hunt M. Developing a MLC modifier program to improve fiducial detection for MV/kV imaging during hypofractionated prostate volumetric modulated arc therapy. J Appl Clin Med Phys. 2019 Jun;20(6):120-124.
2. Gorovets D, Burleson S, Jacobs L, Ravindranath B, Tierney K, Kollmeier M, McBride S, Happersett L, Hunt M, Zelefsky M. Prostate SBRT with intra-fraction motion management using a novel LINAC-based MV-kV imaging method. Pract Radiat Oncol. 2020 May 23:S1879-8500(20)30112-0.

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