Dose Distributions and Comparisons in 3D Lattice Radiotherapy LRT and 2D GRID Beam

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JULY 12–16 2020 VIRTUAL

JOINT AAPM | COMP MEETING

EASTERN TIME [GMT-4]

INTRODUCTION

The objective of this study is to investigate and compare dose distributions in 3D-Lattice radiotherapy (LRT) versus 2D–GRID-"mini"-beam in a treatment planning system.

AIM

Quantitative comparisons of LRT versus GRID planning were conducted for LRT and GRID in spatially fractionated GRID radiotherapy (SFGRT) for bulky tumors.

METHOD

A virtual structure based on the LATTICE or GRID pattern was created and registered to a patient CT image dataset. The virtual structure was positioned in the GTV target with beam geometries to simulate a LATTICE or GRID. This method overcame the difficulty in treatment planning and dose calculation lack of the option to insert a LATTICE or GRID block add-on within the TPS. The dose distribution profile in three axis and the valley-to-peak ratios were evaluated for both 3D-LRT and 2D-GRID.

RESULTS

As shown below, for a deep-seated tumor of 13 x 9 x 13 cm^3 GTV, a GRID-plan in SSD-setup had to prescribe to 9 cm instead of d_{max} of 3.2 cm for 18 MV, in order to maximize penetration. This generated inhomogeneous dose distribution on normal tissue at d_{max} as shown in Figure 1(a). On contrast, 3D-LRT planning achieved high dose vertices within the tumor target as shown in Figures 1(b) to 1(d).

a) on the upper left imaging showing GRID planning in 18 MV beam;

b) on the upper right imaging shown 10 MV-FFF LRT planning; ;

c) on the lower left shown 6 MV-FFF LRT planning;

d) on the lower right low dose-bath in 8.6% in normal tissue beyond GTV for 6 MV-FFF LRT.

LRT generates dose coverage to a deep target compared to the maximum-dose deposition D_{max} occurring at superficial depth in GRID.

The 3D-LRT plans generated high dose vertices within the tumor target regardless of target size and location. The hot-spots were uniformly distributed within the designed spheres in LRT. The valley-to-peak ratios were obtained from the dose profiles of the plan. For the LRT-plan with 6 MV-FFF, anisotropic valley-to-peak ratios centered in GTV were observed at 55.2% laterally, 13.6% longitudinally, and 68.3% along the AP direction, respectively. A low dose bath was exhibited to normal tissues. The 10 MV FFF LRT plan achieved slightly larger numbers. The valley-to-peak ratios were extracted from the dose profiles shown in Figure 2. Valley-to-peak ratios appeared to have directional dependency in LRT RapidArc plans. 6 MV FFF plan achieved smaller valley-to-peak ratios than 10 MV FFF plan.

Figure 2 show comparison of typical dose profiles with the valley–to–peak ratios in different directions in 6 MV FFF beam, in which

a) LRT left–right direction with the ratio of 55.2%;
b) LRT superior–inferior direction with the ratio of 13.6%;
c) LRT anterior–posterior direction with the ratio of 68.3%;
d) GRID left–right direction with the ratio of 32.1% at d_{max}

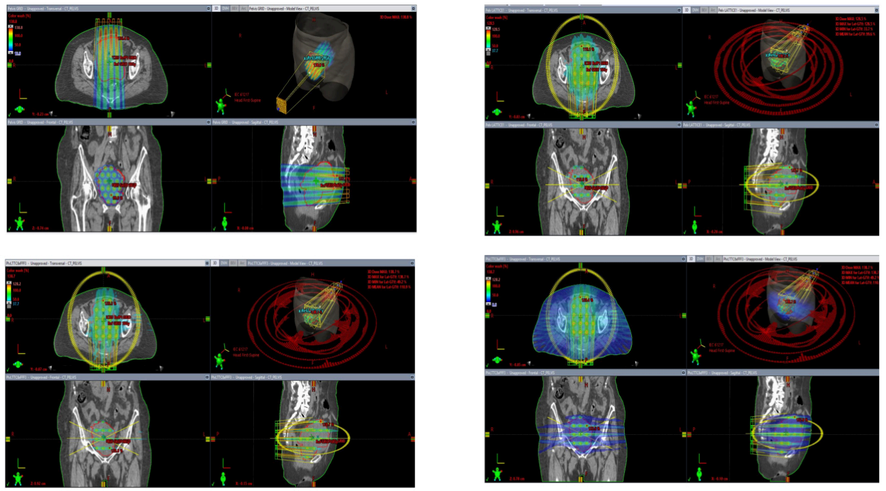

Figure 1: (a) on the upper left shown GRID planning, (b) on the upper right shown 10 MV-FFF LRT planning; (c) on the lower left shown 6 MV-FFF LRT planning; (d) on the lower right low dose-bath in 8.6% in normal tissue beyond GTV for 6 MV-FFF LRT.

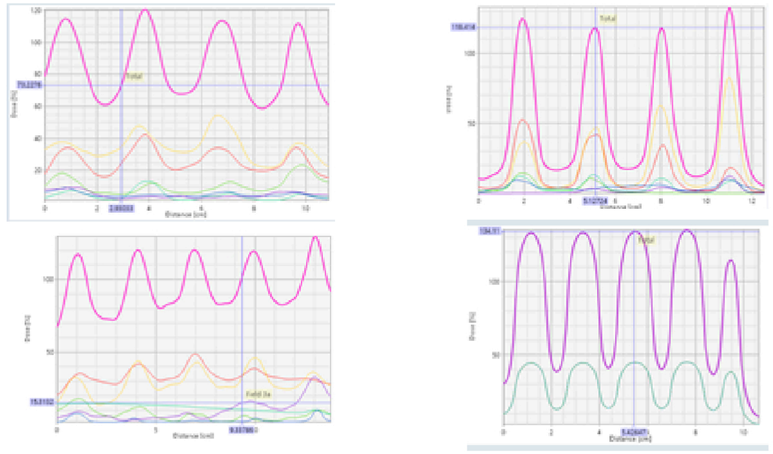

Figure 2: Comparison of typical dose profiles with the valley–to–peak ratios in different directions in 6MV-FFF MV beam: (a) LRT left–right direction with the ratio of 55.2%, (b) LRT superior–inferior direction with the ratio of 13.6%, and (c) LRT anterior–posterior direction with the ratio of 68.3%, and (d) GRID left–right direction with the ratio of 32.1% at dmax.

CONCLUSIONS

Compared to the traditional GRID plan where the maximum dose resided superficially, LRT plans provides improved prescription dose coverage to a deep seated target. LRT plans also achieved comparable, yet directional dependent valley-to-peak ratios. A low-dose-bath is observed in normal tissue in LRT. With higher dose rates in a modern linac, it is deliverable for patient treatments in clinic.

ACKNOWLEDGEMENTS

We wish to acknowledge the supports and encouragement to this study from Northwestern Medicine (NM).

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