



Dosimetric Significance of VMAT Planning Parameters in Prostate Cancer

Kaylan Lawson, Erik Frija, CMD

The University of Texas MD Anderson Cancer Center School of Health Professions

Introduction

With the movement of prostate treatment planning to Volumetric Modulated Arc Therapy (VMAT), it is becoming important to understand how changes in planning parameters influence the overall plan quality in this modality.

This research examines the role arc energy, arc number and arc length play in the quality of prostate treatment plans over a cross section of patients with varying representative body habitus.

Dosimetric quality of said parameters were measured through dose-volume histogram (DVH) analysis on the basis of volumetric dose to organs at risk (OARs), target coverage, and integral dose to the patient. Other parameters considered include patient separation, plan conformity, and number of optimizations required to meet the minimum baseline DVH criteria.

Technique/Goals

- Planning goals were chosen based, in part, by MD Anderson Cancer Center's guidelines and critical structure tolerances
- At least 98% of the PTV covered by 100% of the prescription dose (78Gy), with the volume of 78Gy to not vary from the volume of the PTV by greater than 3.5% to ensure precise conformity

Table 1 Average mean NT doses (in cGy) for patients grouped by (cm) separation for full arc plans

	6x 2arcs	10x 2arcs
30-35 Separation	1254	1217
35-40 Separation	1117	1190
40-45 Separation	922	924
45-50 Separation	1045	1060
50-55 Separation	965	955

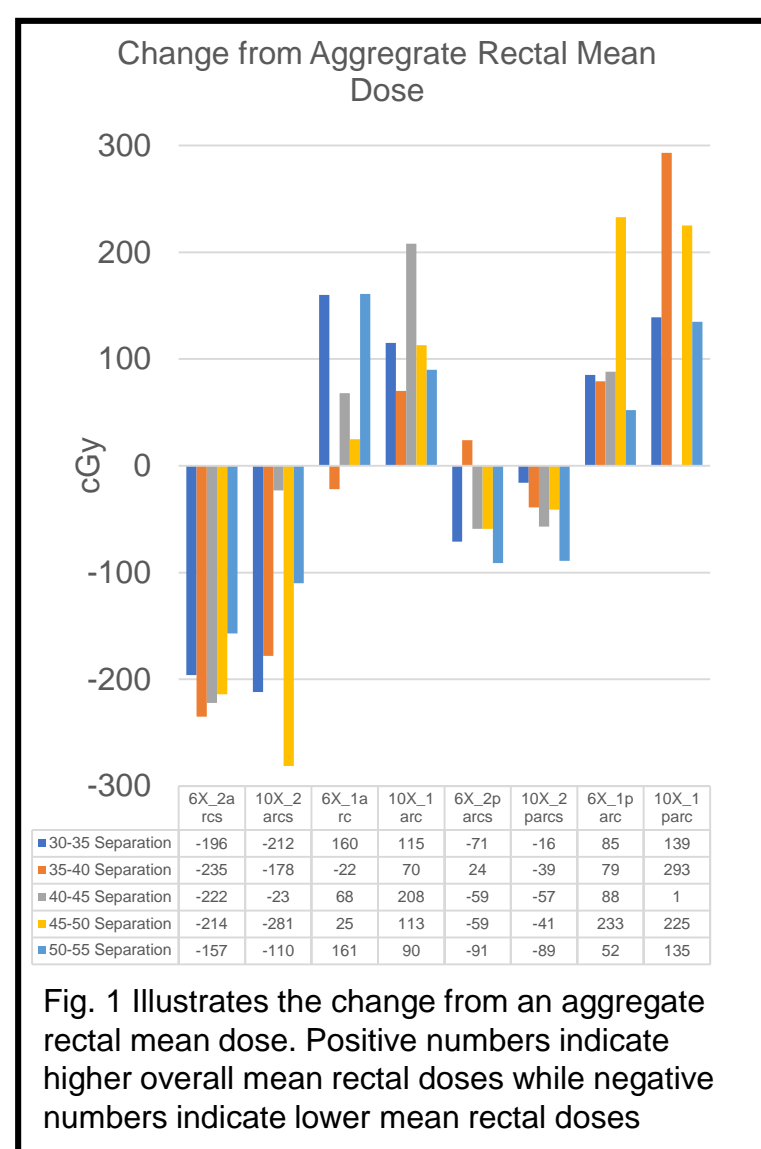


Fig. 1 Illustrates the change from an aggregate rectal mean dose. Positive numbers indicate higher overall mean rectal doses while negative numbers indicate lower mean rectal doses

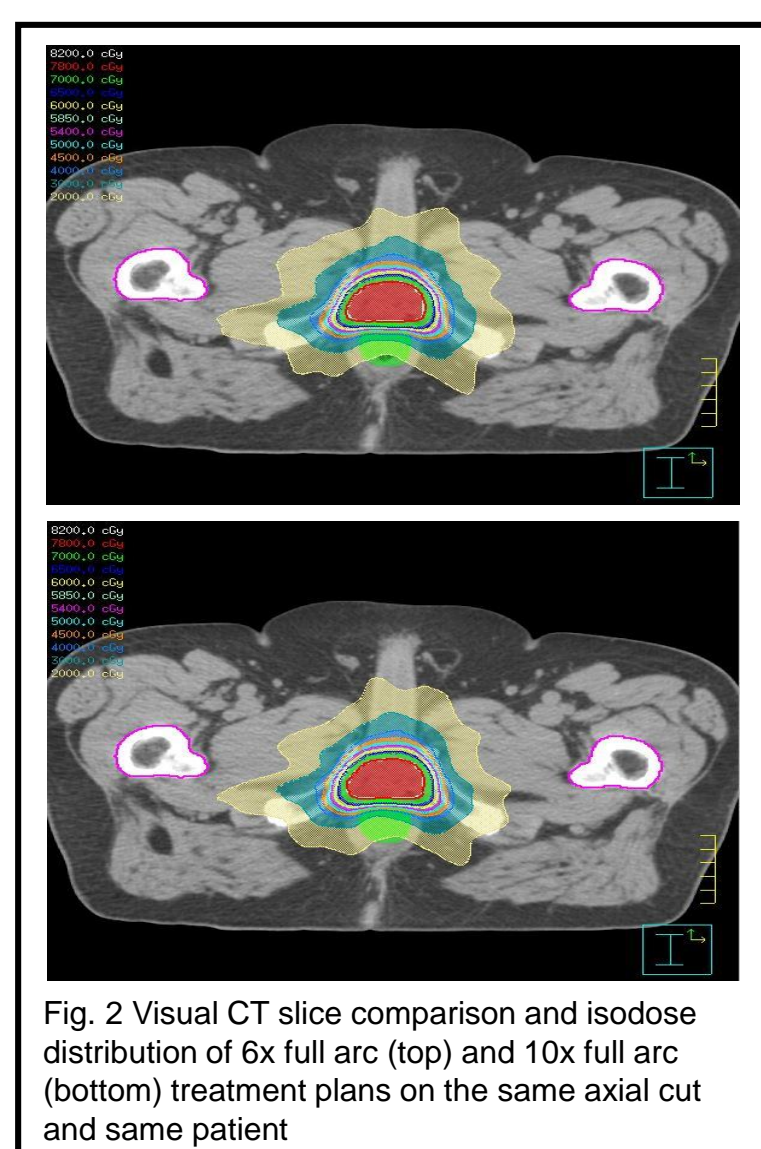


Fig. 2 Visual CT slice comparison and isodose distribution of 6x full arc (top) and 10x full arc (bottom) treatment plans on the same axial cut and same patient

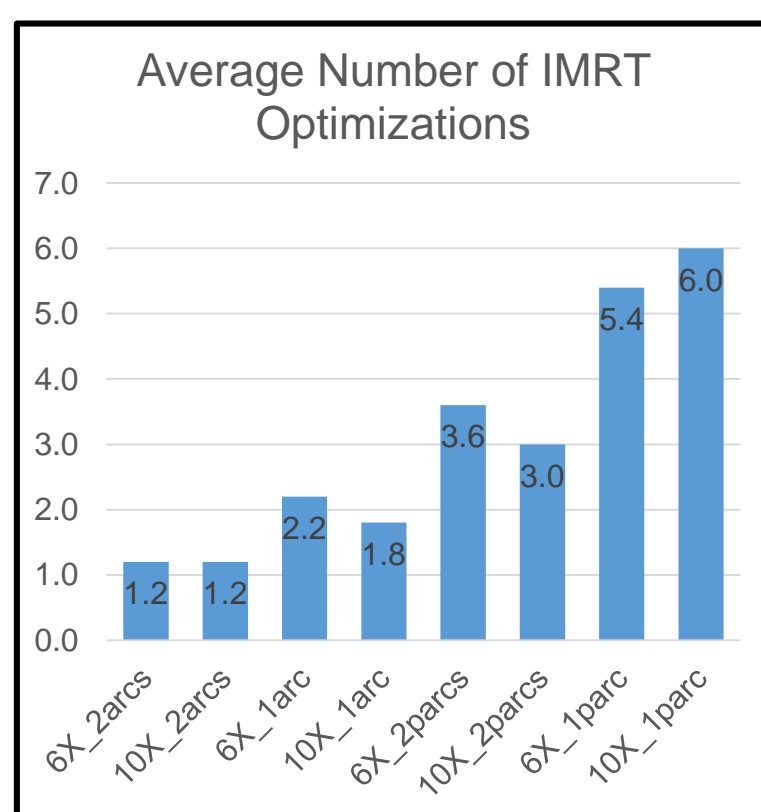
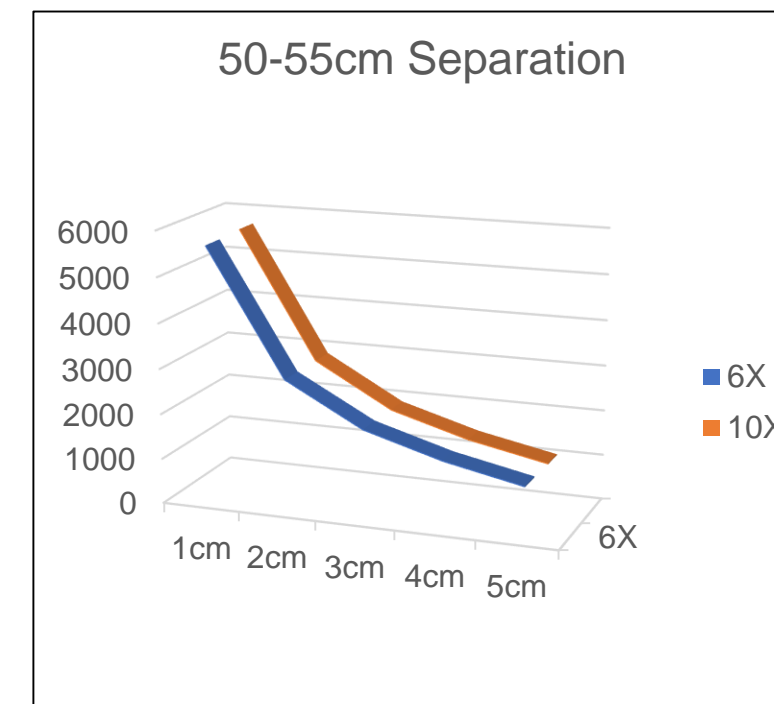
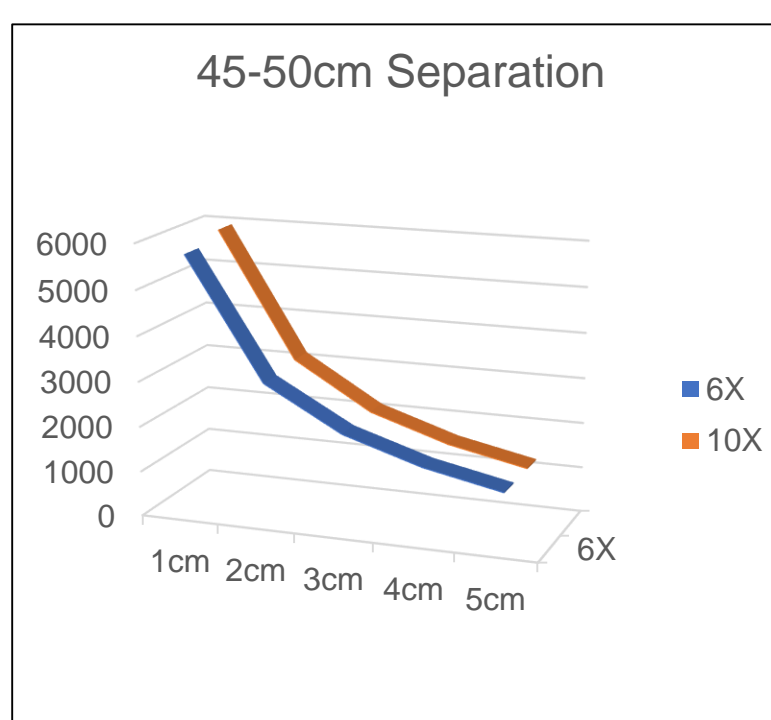
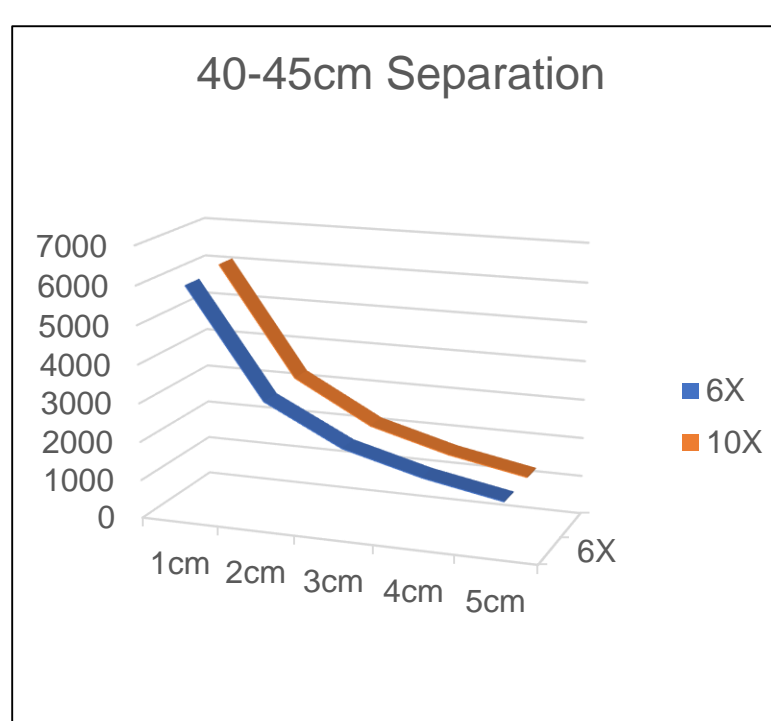
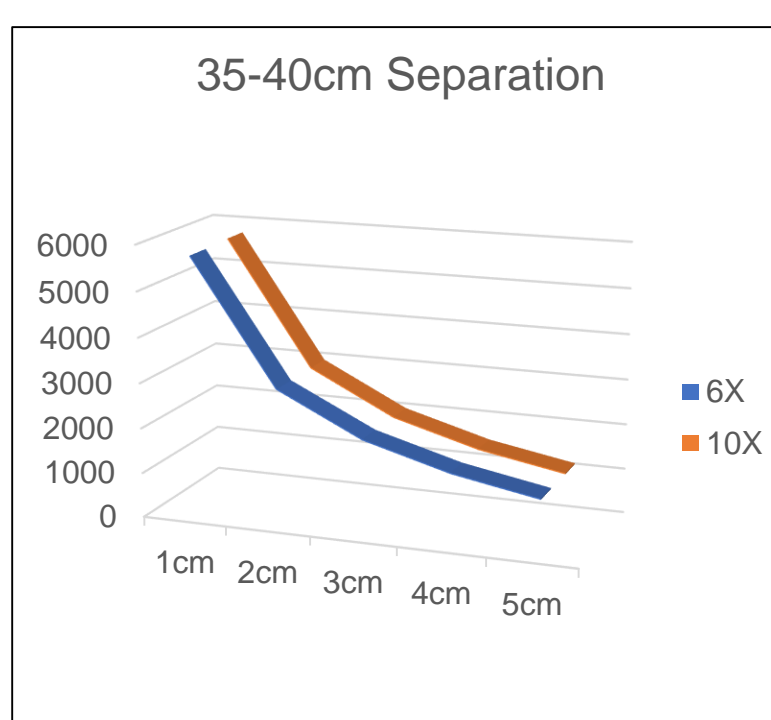
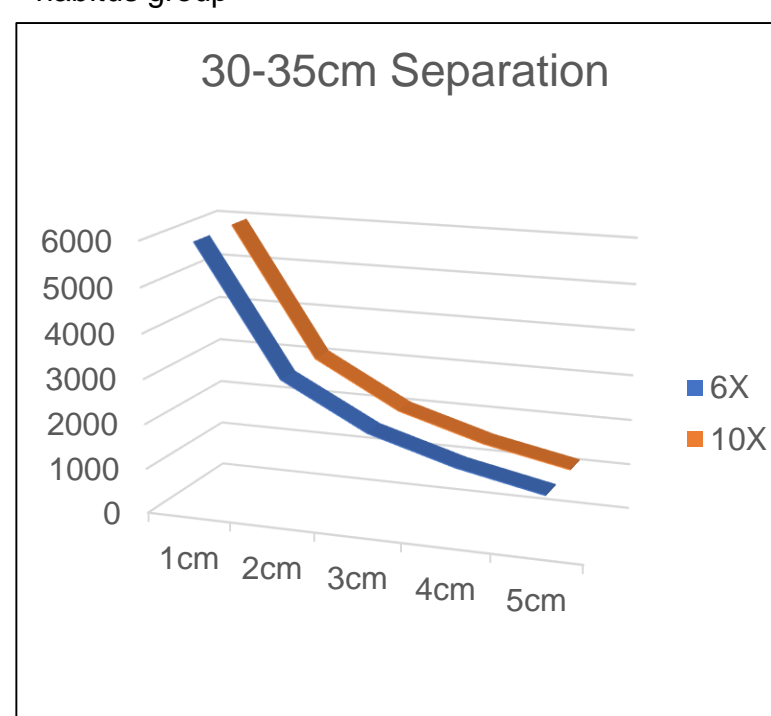


Fig. 3 The average number of IMRT refinement optimizations for differing modalities

Methods

Pinnacle TPS version 9.10 was used to generate VMAT plans for prostate cancer treatment. For each patient, a variety of treatment planning ideologies were employed then compared to determine the effects on plan quality correlated to body habitus.

Fig. 4 Superimposed line plots of dose fall-off for 6x and 10x full arc plans for each respective body habitus group



Technique/Goals

- V70 of the rectum not to exceed 12%
- V30 of the rectum not to exceed 50%
- V70 of the bladder not to exceed 15%
- V30 of the bladder not to exceed 40%
- V45 of both femoral heads not to exceed 5%
- PTV delineated by expanding the prostate and relevant seminal vesicles by a margin of 0.4cm posterior, and a 0.6cm margin right, left, superior, and inferior
- Max point dose to any volume not to exceed 82.5Gy
- 30Gy isodose line to not visually extend further than 3cm from the PTV to ensure low dose conformity

Methods

The number of arcs were varied, 1 vs. 2; as were the arc lengths, full vs. 320 degree rectal sparing partial arc. For each arc variation, plans were generated for both 6x and 10x energies.

Plan quality was measured based on maximum and mean doses to pelvis critical structures, overall isodose volumes to decreasing percentages of the total prescription as well as maximum and mean doses to overall tissue volumes at increasing distances from the target.

Results

For patients of all body habitus, increasing energy had no statistically relevant impact on the max/mean dose for critical structures. Furthermore, increasing energy had little to no impact on dose conformity or overall integral dose regardless of patient size.

VMAT planning with 2 full arcs was found to be consistently superior to plans with a single arc. Plans with 2 partial rectal sparing arcs provided similar, but not superior, plans to 2 full arcs; however, partial arc plans required significantly more iterative adjustments to arrive at plans with similar quality.

Figure 1 shows the highest mean doses to the rectum belong to all single arc modalities, with both single partial arc groups delivering the highest overall mean rectal doses. Conversely, all 2 arc plans resulted in rectal doses lower than the aggregate mean regardless of body habitus. Interestingly, while 2 partial arc modalities resulted in relatively low mean rectal doses, the 2 full arc 6x and 2 full arc 10x treatment modalities consistently delivered the lowest overall mean rectal doses for nearly all plans.

Conclusions

In the VMAT treatment of prostate cancer, the use of 2 full arcs consistently offers higher quality plans than 1 full arc plans or any plans with partial arcs.

Additionally, 10x energy offers no real dosimetric advantage over 6x energy regardless of body habitus.

The conclusion that higher energy offers no advantage for larger patients is paradoxical and contrary to many current dosimetry mores yet is consistently supported by data.