Sensitivity Analysis of Common Beam Modeling Parameters in the Eclipse Treatment Planning System on IROC Head and Neck Phantom Results

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INTRODUCTION

Recently, the accuracy of beam modeling parameter configuration has come into question, as IROC Houston determined that considerable treatment planning system errors exist among institutions that fail its phantom credentialing test. This pilot study for Eclipse was prompted to determine which parameters are most critical for accurate model creation and to what extent variations in calculation accuracy may be realistically attributed to parameter value assignment, given that these values were surveyed from the radiotherapy community at large.

METHODS

1. Commissioned a 6 MV beam model for a standard Varian Clinac 2100iX in Eclipse (AAA 13.5.35) to represent an “average” performance machine. Parameters were chosen to match IROC Houston site visit dosimetric data (e.g. output factors, PDDs) and median beam modeling parameter values from a survey of over 600 institutions.
2. Imported 10 clinically-acceptable H&N phantom plans (4 IMRT and 6 VMAT) from IROC credentialing participants
3. Recalculated dose for each plan after individually manipulating beam modeling parameters following the 2.5th, 25th, 50th, 75th, and 97.5th percentiles of IROC survey responses (Table 1)

Table 1. Eclipse beam modeling parameter characteristics of Varian Clinac machines (as determined by survey of 642 radiotherapy clinics).

		Source Size X [mm]	Source Size Y [mm]	DLG [cm]	MLC Transmission
	N	298	298	312	309
Percentile	2.5	0.00000	0.00000	0.04825	0.01160
	25	0.00000	0.00000	0.15000	0.01405
	50	0.00000	0.00000	0.17000	0.01580
	75	0.00000	0.00000	0.18850	0.01680
	97.5	1.50000	1.00000	0.23518	0.02200

RESULTS

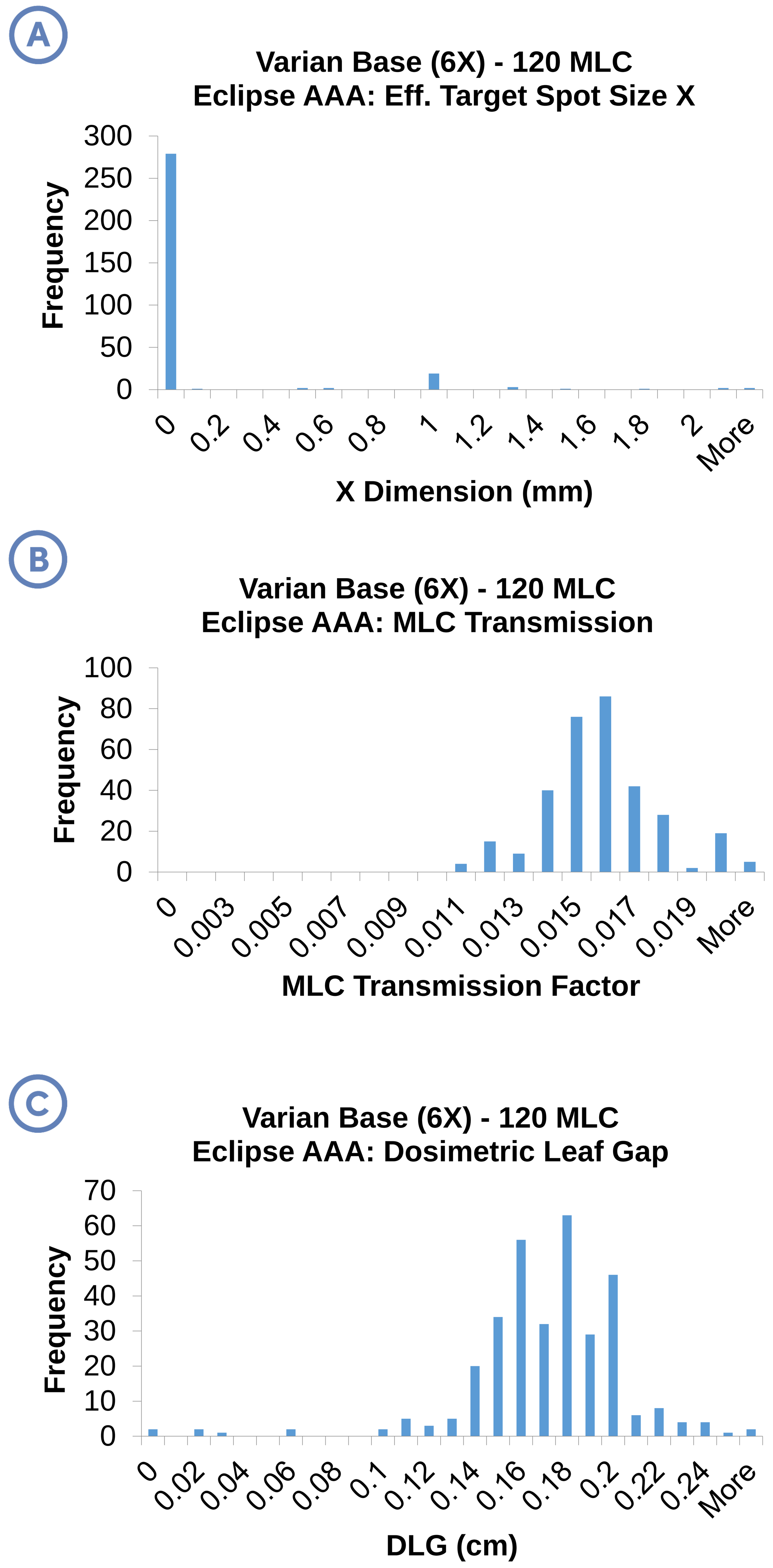

Figure 1. Survey response histograms of (a) effective target spot size, (b) MLC transmission, and (c) dosimetric leaf gap for Varian Clinac-type systems using Eclipse AAA. Note that the spot size (a) shows excellent uniformity, whereas other parameters display greater disparities.

- Effective Target Spot Size: Greatest change in dose <0.7%; 90% of survey respondents using a Varian Clinac-type machine cited 0 x 0 mm (Fig. 1), thus very little change could be observed.
- MLC Transmission Factor: Observed changes in dose up to ±1%
- Dosimetric Leaf Gap: Significant changes in dose from -6% to +3%

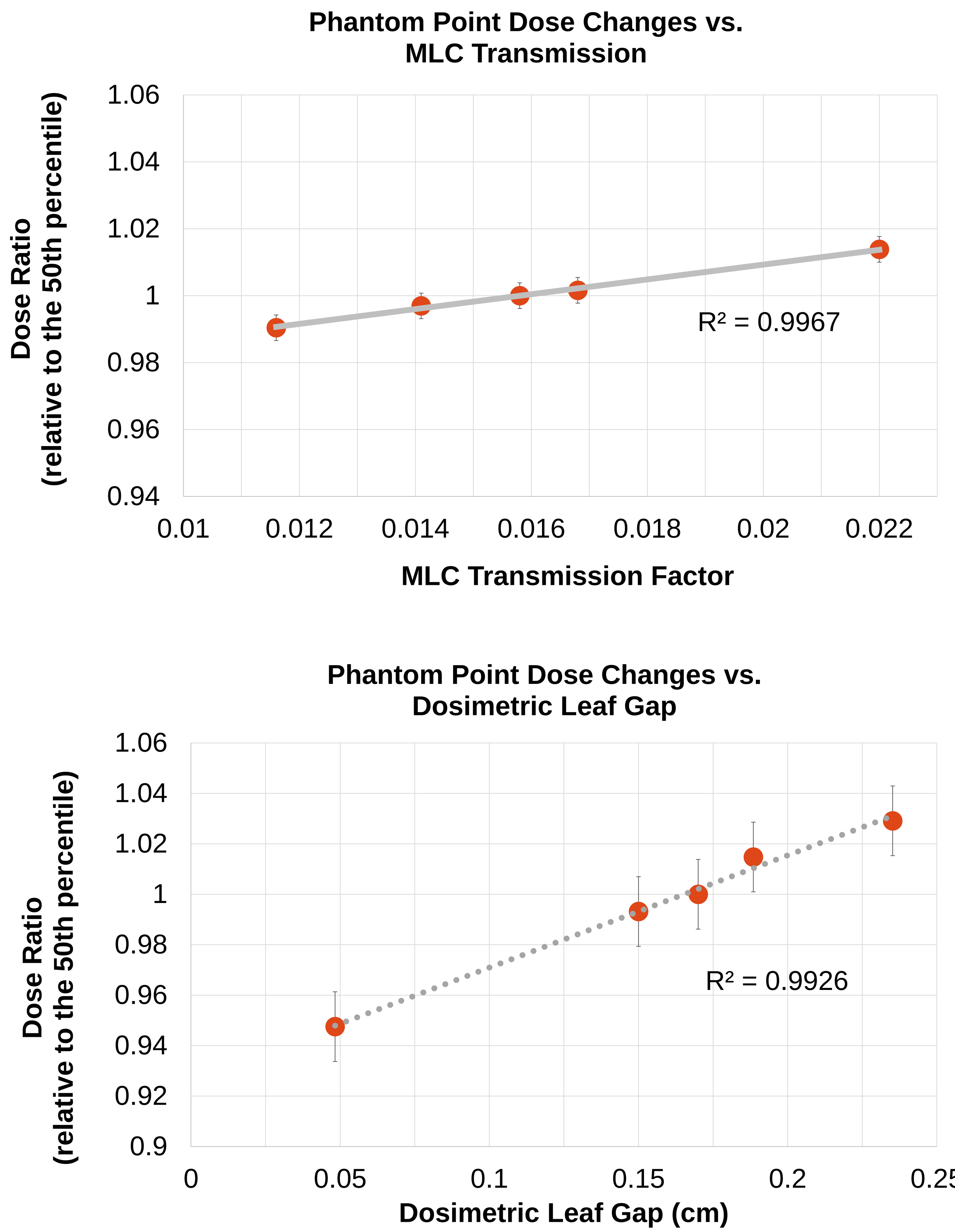

Figure 2. Trend lines depicting the average change in dose to TLD structures (point doses) in the phantom PTVs for all 10 phantoms observed when the MLC transmission factor (top) and dosimetric leaf gap (bottom) are modified according to the range of survey results. Dose ratios are relative to the 50th percentile, which served as the reference model value.

DISCUSSION

Based on TPS beam modeling survey results and this work, it is apparent that parameters that were physically measured (e.g. DLG and MLC transmission) exhibit the greatest variation in modeling, and subsequently, the greatest changes in dose. Such differences may be attributed to using disparate measurement methods or unsuitable equipment for measurement.

CONCLUSIONS

This study demonstrates that considerable variation exists in several TPS beam modeling parameters, thus highlighting the need careful consideration in the commissioning of clinical beam models, especially regarding the measurement of the DLG. The use of parameter values deemed clinically acceptable, but are far from typical, are shown to potentially contribute to failing phantom results and significant deviations in dose calculations.

In future works IROC Houston will be closely monitoring incoming phantoms for TPS-related errors to better diagnose how such errors occur and better inform the radiotherapy community.

ACKNOWLEDGEMENTS

- This work is supported by Public Health Service Grants CA180803 and CA214526, awarded by the National Cancer Institute, U.S. Department of Health and Human Services.
- Mallory Glenn is a recipient of the Rosalie B. Hite Fellowship and American Legion Auxiliary Fellowship in Cancer Research, awarded by the MD Anderson Cancer Center UTHealth Graduate School of Biomedical Sciences.

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