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Modeling MLC and Jaws Effective Position Correction of An Elekta Synergy Accelerator with An Agility Head in RayStation

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING EASTERN TIME [GMT-4]

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INTRODUCTION

Model accuracy is a critical prerequisite of treatment planning system commissioning. RayStation (RaySearch Laboratories, Stockholm, Sweden) provides a series of automated routines which facilitate the modeling process. However, these routines are designed to optimize the parameters directly related to the beam itself (e.g. energy spectrum, off-axis softening or other source properties) using open fields measurements with simple geometries. Several MLC-related parameters (transmission, tongue and groove, leaf tip width, offset and gain calibration) can, and should, also be adjusted in the model. These MLC parameters can have a major dosimetric impact for highly modulated plans[1], but are not part of the optimization routines. Moreover, the dosimetric impact of MLC parameters is difficult to assess inside the Beam commissioning module of RayStation.

AIM

A systematic method to evaluate the MLC parameters in RayStation (version 7) is presented. In this work, the purpose is to determine the offset, gain and curvature of jaws and MLC used to correct the nominal field size (FS) for a beam model of an Elekta Agility accelerator. Another related work by the same authors (Poster PO-GeP-T-461) addresses other MLC related parameters (MLC transmission, MLC y-position gain, tongue and groove and leaf tip width). A general methodology for an optimal modelling process has been described but provides no detail of the resulting parameters[2]. Another work have reported some results for a Varian Millennium[3], but to our knowledge no work have reported values specific for an Elekta Agility.

METHOD

Symmetric FS ranging from 1x1 to 24x24 were measured with portal imaging for three photon energies (6, 10, 18 MV) on four matched accelerators. All FS measurements were repeated three times with portal imaging for each energy and room combinations to fully account for the variability. Spot check measurements of FS were performed with radiochromic films to validate portal measurements. All analyses were performed solely on portal images with an in-house program (Matlab, MathWorks, Natick MA, United States). The difference between the measured and nominal FS was calculated and plotted as a function of nominal FS for all energy-axis combinations (total of six curves). In RayStation, this quantity is termed the "field size correction" (FSCorr) and is defined as:

$$\text{Eq. (1)} \quad FSCorr = FS_{measured} - FS_{nominal} = Offset + Gain \cdot FS_{nominal} + Curvature \cdot FS_{nominal}^2$$

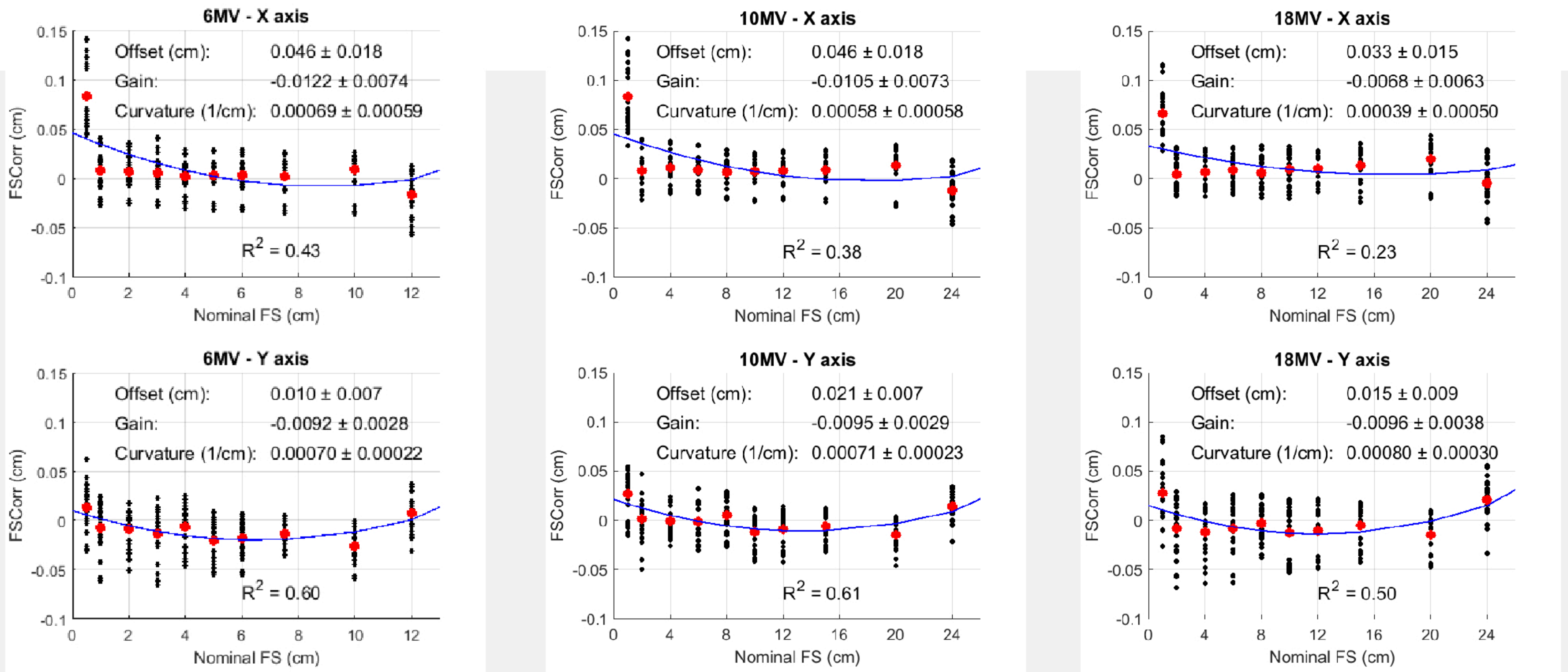
A FSCorr is defined independently for each energy and axis. Because the correction in RayStation is symmetric, the determination of the isocenter position is not critical as the individual collimations (e.g. X1 and X2) are not needed. Data from all rooms and all repeated measurements for a given energy and nominal FS were averaged to obtain an average FSCorr per nominal FS. A 2nd order polynomial curve adjustment was performed on each curve to obtain the offset, gain and curvature. The statistical significance of the fitting parameters and the correlation were evaluated. The curve fitting and correlation analysis were performed in Matlab. A pure quadratic regression was done with the `fitlm` function. According to the equation above, the fitting parameters represent directly offset (intercept), gain (linear term) and curvature (quadratic term).

RESULTS

The figures on the right show the detailed results for each energy and axis. X axis represents MLC and Y axis represents jaws. Black dots on the plots represent all individual FSCorr calculated from measurements made with portal imaging. Red dots represent the average FSCorr for a given FS. The blue curve represent the adjusted quadratic function obtained using Eq. (1). The correlation for each curve is shown directly on the graphs. The fitting parameters are also shown directly on the graphs as ([estimate]±[standard error]). The number of decimals is consistent with what is allowed in RayStation. The statistical significance for each fitting parameter is show in the table below. Parameters for which p<0.05 are highlighted in green in the table and are considered statistically significant.

Y-jaws gain and curvature were significant ($p<0.05$) for all energies. Y-jaws offset was significant only for 10 MV. Gain and curvature values for MLC x-position were not significant for any energy. MLC x-position offset was significant for 6 MV and 10 MV. The correlation for all six curves was weak ($R^2 \leq 0.61$).

p-value for fitting parameters						
	6 MV		10 MV		18 MV	
	X axis	Y axis	X axis	Y axis	X axis	Y axis
Offset	0.042	0.187	0.0388	0.0212	0.0679	0.1554
Gain	0.147	0.0138	0.1918	0.0137	0.3210	0.0408
Curvature	0.294	0.0168	0.3539	0.0185	0.4710	0.0343



CONCLUSIONS

RayStation allows to correct the effective jaws/MLC positions to account for position-dependant correction of FS. The offset, gain and curvature were evaluated for both axis (MLC and jaws) for an Elekta Agility. These corrections were either non significant or weakly correlated due to high variability in FS measurements. Gain and curvature could be set to zero for all axis and energies with negligible impact on the model. Offsets, although non significant for FS correction, could be used to achieved other modeling goals, such as output adjustment for IMRT plan.

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