Comparison of Location Accuracy between the Jaw and MLC Using a High Sampling Rate Log File

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M. Seo, S. Nishiyama, K. Makabe, M. Kuramochi, T. Suzuki, H. Tomita
Department of Radiation Technology, Saiseikai Kawaguchi General Hospital, Saitama, Japan

INTRODUCTION

Regarding the volumetric modulated arc therapy (VMAT) and intensity-modulated radiation therapy (IMRT) plans, there are reports that the multi-leaf collimator (MLC) position accuracy is evaluated by a high-sampling-rate log file (HLF)[1], but there is no report of the jaw position accuracy being verified by using an HLF in the Elekta Synergy with Agility head. This method allows for visualization of the jaw position during irradiation and is useful for evaluating the jaw's internal control in the plan.

AIM

We compared the positional accuracy of the jaw and MLC in the Elekta Synergy with Agility head using a HLF.

METHOD

- A Dynamic Jaw (DJAW) plan was created in which the Y jaw that maintained the 10 mm gap moved from the Y1 side to the Y2 side between the two control points (CP) and then returned to the starting position.
- The plan changed the moving speed in seven steps (5, 10, 15, 20, 25, 30, 35 mm/sec), and further changed the gantry angle and the collimator angle in three steps (Ga0° /Co0° , Ga90° /Co90° , Ga270° /Co90°). The HLF was acquired at the same time as the beam irradiation.
- Next, we created a similar dynamic MLC (DMLC) plan and obtained an HLF.
- Each acquired log file was imported into our software, and the maximum error, mean absolute error (MAE) and root mean square error (RMSE) of the Y jaw and MLC(leaf No.41) were compared.
- In addition, the plotting positions of the jaw and MLC recorded in the HLF for each sampling time and the theoretical jaw and MLC positions between CPs were visualized and compared.

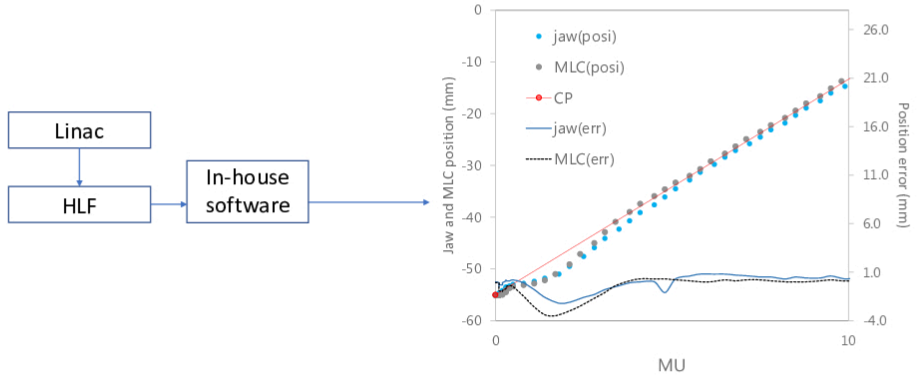

Figure 1: Visualization of the jaw and MLC plots in the dynamic plan

RESULTS

- Figure 2 shows the results of plotting the Y1, Y2, and MLC positions. There was no significant difference in the maximum error between the Y1 and Y2 positions (p=0.387).
- Table 1 shows the maximum error, MAE and RMSE at 35 mm/sec. The maximum value of RMSE in the jaw was 0.8 mm, and did not exceed the allowable value of 1.0 mm[2], regardless of the gantry angle. A one-way analysis of variance was performed and there was no significant difference in the maximum jaw error at each gantry angle (p=0.120).
- The maximum error in the jaw was 3.3 mm at a gantry angle of 270° at 35 mm/sec, and the maximum error in the MLC was 4.2 mm when the gantry angle was 0° . In both the jaw and the MLC, the maximum error increased as the moving speed increased (Figure 3).
- Figure 4 shows the results of plotting the jaw and MLC positions and comparing them with the CP. At the turning point, the MLC overshoot the CP, while the jaw failed to reach the CP (Figure 5). This phenomenon occurred even when the gantry angle was changed, and reproducibility was observed for each measurement(Figure 6).

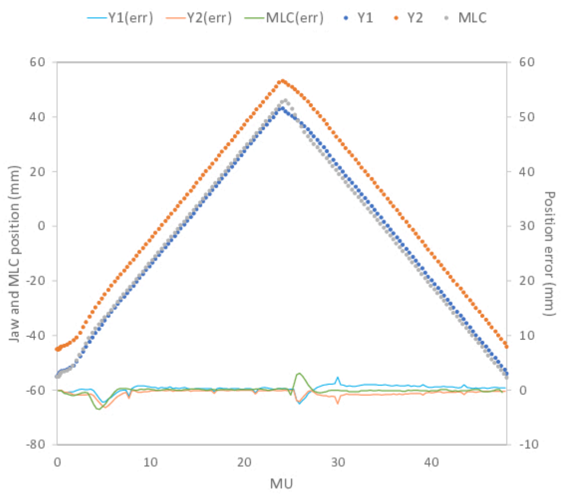

Figure 2: Comparison of plots between the Y1 and Y2 positions at a gantry angle of 0° at 35 mm/s

Table 1: The jaw and MLC position error for each gantry angle at 35 mm/s

	Maximum error (mm)		MAE (mm)		RMSE (mm)	
	jaw(Y1)	MLC	jaw(Y1)	MLC	jaw(Y1)	MLC
Gantry: 0°	3.0 (0.4)	4.2 (0.6)	0.6 (0.0)	0.4 (0.1)	0.8 (0.1)	0.9 (0.1)
Gantry: 90°	2.7 (0.3)	3.7 (0.4)	0.4 (0.0)	0.4 (0.0)	0.6 (0.1)	0.8 (0.1)
Gantry: 270°	3.3 (0.12)	3.9 (0.3)	0.6 (0.0)	0.4 (0.0)	0.8 (0.0)	0.9 (0.1)

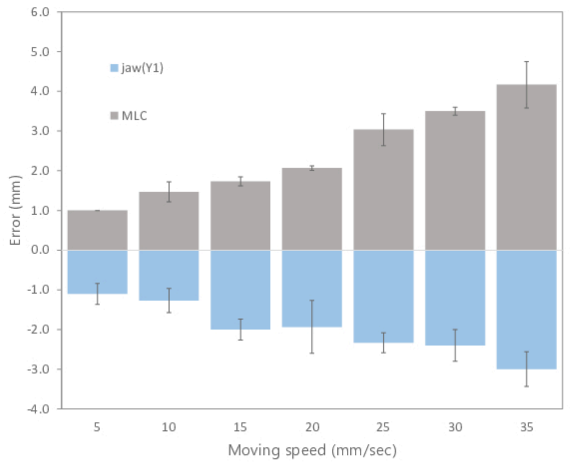

Figure 3: Comparison of the maximum error between the jaw and MLC at a gantry angle of 0 °

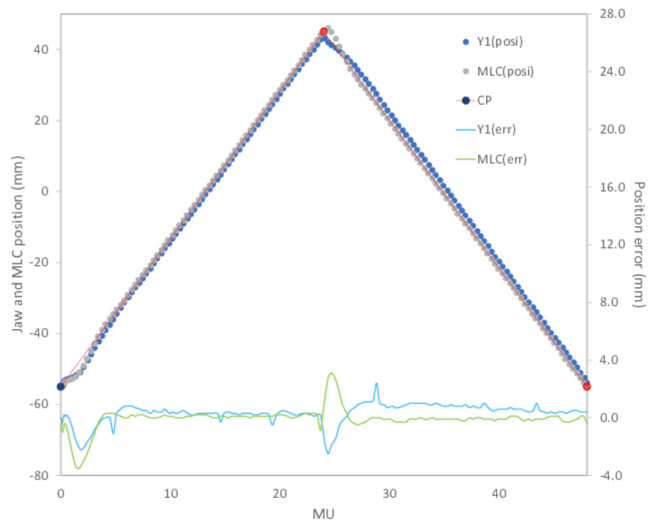

Figure 4: Comparison of plots between the jaw and MLC at a gantry angle of 0° at 35 mm/s

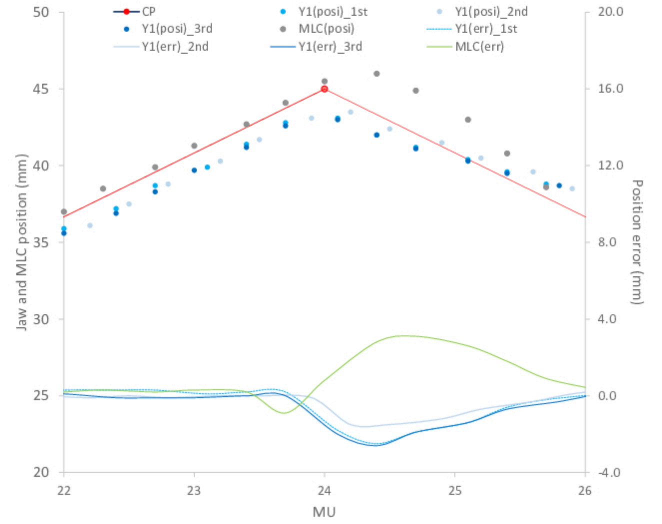

Figure 5: Comparison of how to move when turning at a gantry angle of 0° at 35 mm/s

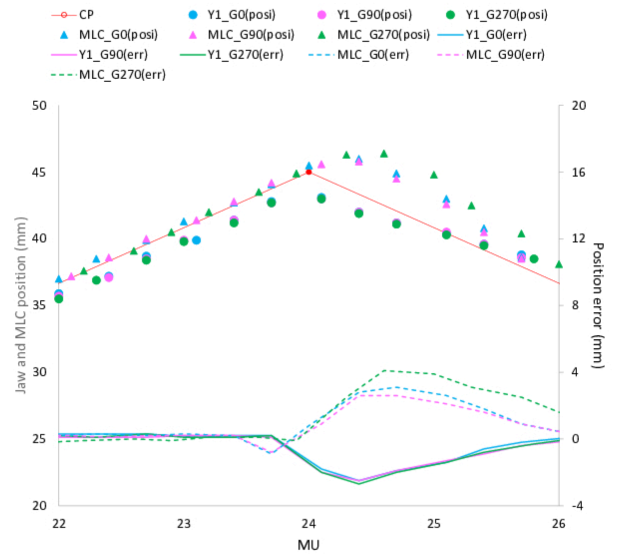

Figure 6: Comparison of how to move when turning at each gantry angle at 35 mm/s

CONCLUSIONS

- There was a difference in behavior between the jaw and MLC at the folding point in CP. In the device used, the jaw is driving the motor, while the MLC is using an optical camera. This difference in control system is assumed to be the underlying cause. In contrast to the verification plan, in this instance, the VMAT plan used in clinical practice is more likely to have position errors because jaws movement is more complicatedly. If the jaw position error is large, it may affect the dose error; therefore, it is necessary to verify this relationship[3][4][5]. Since the jaw is an important parameter that forms the irradiation field similar to that of MLC, we believe that a detailed quality control method using an HLF is useful.
- Using an HLF to visualize and analyze the positional error during irradiation, enabled us to confirm the difference in behavior between the jaw and the MLC.

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CONTACT INFORMATION

5-11-5 Nishikawaguchi, Kawaguchi City, Saitama, Japan
TEL.: +81-48-253-1551
E-mail: barca8so6ccer@gmail.com