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Establishing Systemwide SRT Transferability between Heterogeneous MLC and RTP Systems.

Sumudu Katugampola, PhD; Evan G. Meekins, MS; Ian J. Butterwick, MS; Saina Ahmadpour, MS and ChangSeon Kim, PhD

Geisinger Medical Center, Danville, PA

ABSTRACT

Purpose: To develop and validate a methodology for assessing SRT patient transferability from an HD MLC LINAC with the BrianLab treatment planning system(TPS) to a standard Millenium MLC (SM MLC) LINAC planned with Eclipse TPS, with the goal of enabling systemwide implementation within a multi-site institution.

Methods: MLC output factors (OF) of the SM MLC were measured for field sizes, 1x1,2x2, 3x3, 4x4, and 10x10 cm, and compared with Eclipse TPS calculations. Dynamic conformal arc (DCA) plans for the evaluated field sizes were generated in Eclipse for both HD MLC and SM MLC configurations and resulting dose distributions were compared using gamma analyses. A similar analysis was performed for spherical targets of diameters: 1-5 cm. Additionally, five clinical SRT cases (PTV volumes: 0.6 – 17 cc) were planned using Brainlab for HD MLC delivery and replanned in Eclipse for the SM MLC machine, with corresponding dose distributions compared using Gamma analysis. For patient-specific QA of the SM MLC system, the portal dosimetry (PD)results were compared against those of an SRS MapCHECK (PTV volumes: 0.3-19cc).

Results: Eclipse-calculated OFs for SM MLC agreed with measurement within 0.75%for field sizes ≥3x3 cm. Gamma passing rates for DCA plans comparing HD MLC and SM MLC exceeded 97% for field sizes ≥3x3 cm and exceeded 93% for PTV diameters ≥3cm. Dose distributions from Brainlab for the HD MLC and Eclipse for SMMLC demonstrated Gamma > 99% across all evaluated PTV sizes. PD results showed strong agreement with SRS MapCHECK measurements.

Conclusion: A robust methodology for transferring SRT patients between Brainlab-planned HD MLC and Eclipse-planned SM MLC platforms were developed and validated. This framework establishes a foundation for standardizing SRT planning and delivery across heterogeneous LINAC and RTP environments and will be expanded to enterprise-level implementation within a multi-site network.

CONTACT

Sumudu Katugampola
Geisinger Medical Center
Danville, PA, USA
skatugampola@geisinger.edu

INTRODUCTION

The study presented here introduces a validated methodology for assessing stereotactic radiotherapy (SRT) patient transferability between heterogeneous treatment planning and delivery platforms, specifically from BrianLab-planned treatments delivered on a high-definition MLC (HD MLC) system to Eclipse-planned treatments delivered on a standard Millenium MLC (SM MLC) system.

The study defines a structured set of dosimetric and delivery tests to assess small-field limitations, quantify target-size dependent agreement, and verify consistency in treatment planning system dose calculation and delivery accuracy across disparate platforms.

By identifying both performance thresholds and verification requirements, this methodology supports confident cross-flatform SRT patient transfer. Importantly, the approach is designed for systemwide scalability, making it particularly well suited for multi-site institutions seeking to standardize SRT workflows, improve operational resilience, and maintain consistent treatment quality when patient transfers between LINACs or sites are required.

METHODS AND MATERIALS

The study consisted mainly of two parts: 1. Assessing the limitations of SM MLCs compared with HD MLCs. 2. Compare overall differences between Brainlab plans with HD MLCs and Eclipse plans with SM MLCs. This was achieved by performing the following tests.

- MLC OFs were measured (in solid water) for field sizes: 1x1,2x2, 3x3, 4x4, and 10x10 cm^2 and compared with Eclipse TPS values.
- Dynamic conformal arc plans, generated in Eclipse from SM and HD MLCs were compared using a Gamma analysis. Field sizes used: 1x1,2x2, 3x3, 4x4, and 10x10 cm^2 .
- Dynamic conformal arc plans, generated in Eclipse from SM and HD MLCs were compared using a Gamma analysis for spherical targets. Diameter range: 1- 5 cm.
- Five clinical SRT plans were created in BrainLab (BL) for HD MLCs and re-created them in Eclipse for SM MLC. PTV vols: 0.6 - 17cc.
- Plan-to-plan comparisons were made using Gamma analysis.
- Finally, deliverability of Eclipse plans with SM MLCs were tested with both PD and SRS Mapcheck results.

RESULTS

- OF measurements for HD MLCs agreed with TPS to within 0.75%, for field sizes larger than 3x3 cm^2 (Fig. 1).
- Gamma passing rates comparing HD and SM MLC for DCA plans were above 97% for field sizes > 3x3 cm^2 (Fig. 2) and were above 93% for PTV vol > 3cc (Fig. 3).
- Comparison results of BL-generated clinical SRT plans with HD MLCs and Eclipse-generated same plans with SM MLCs are shown in Fig. 4. Dose distributions agree with Gamma passing rates above 99% for PTV sizes: 0.6-17cc.
- Quality assurance (QA) results for the Eclipse-generated clinical plans with SM MLCs are shown in Fig. 5 (PTV sizes: 0.3 – 19 cc).
- PD results were in agreement (Gamma passing > 99%) with SRS Mapcheck results (Fig. 5).

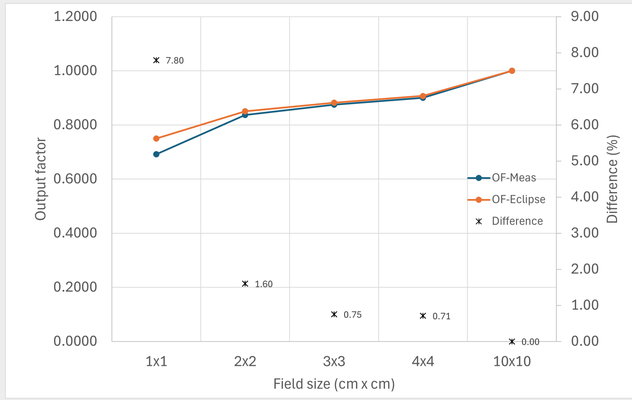

Figure 1

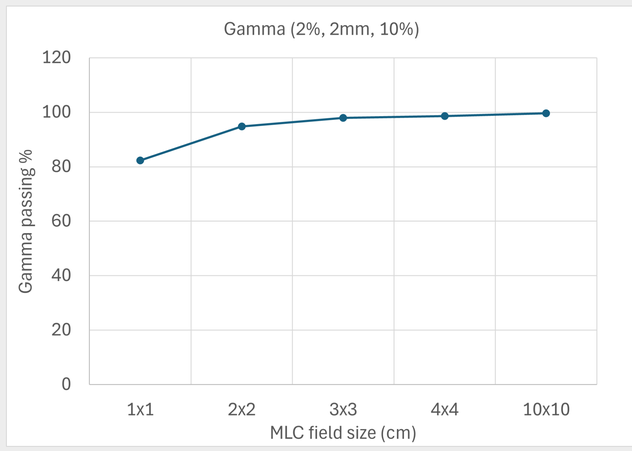

Figure 2

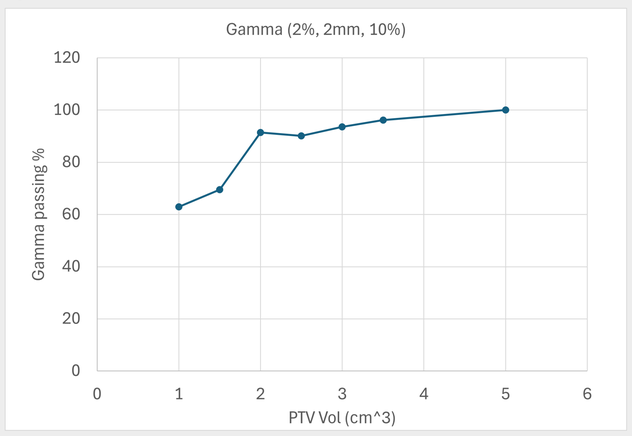

Figure 3

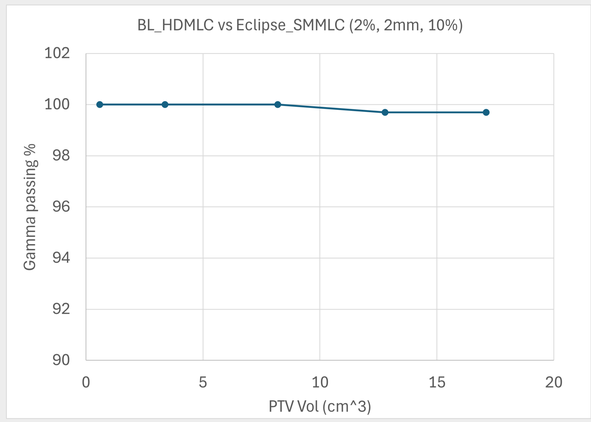

Figure 4

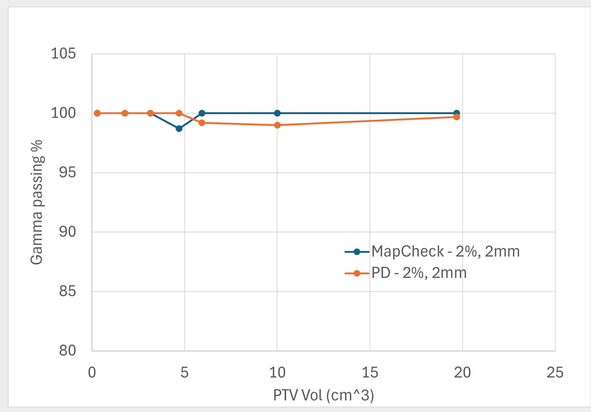

Figure 5

DISCUSSION

The combined results of output factor measurements for the HD MLCs and the inter-comparison of HD and SM MLCs confirmed that the PTV volumes greater than 3cc can be effectively treated with SM MLCs. The Brianlab-generated SRT plans with HD MLCs and their Eclipse versions with SM MLCs indicated that the former can be successfully replaced by the latter down to PTV volumes of 0.6cc. Finally, the deliverability and dosimetric verification of the above converted, Eclipse-generated SM MLC plans formalized the overall patient transferability from a Brainlab-based HD MLC system to an Eclipse-based SM MLC system.

Furthermore, the confirmation of the patient specific QA accuracy of the portal dosimetry system by the SRS Mapcheck indicated the overall applicability of the portal dosimetry system in the full range of PTV volumes studied (0.3 – 19 cc). Considering all the results, it can be identified that the smallest diameter of the PTV that can accurately be treated by the SM MLC platform is 2 cm.

This approach is designed for systemwide scalability, making it particularly well suited for multi-site institutions seeking to standardize SRT workflows, improve operational resilience, and maintain consistent treatment quality when patient transfers between LINACs or sites are required.