

An Investigation of using Logfile Analysis for Automated Patient Specific Quality Assurance in MRgRT

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INTRODUCTION

Adaptive radiation therapy (ART) is an integral part of MR-guided RT (MRgRT), requiring a new RT plan for each treatment fraction and resulting in a significant increase in patient specific quality assurance (PSQA). Currently, there is no commercial product that can automatically perform log file analysis for the 1.5T Unity MR-Linac. This study investigates the possibility of using treatment log file for automated PSQA.

AIM

- To investigate the possibility of modifying an existing commercial product to perform logfile analysis of the new 1.5 Unity MR-Linac.
- To investigate the feasibility of using logfile analysis for PSQA by comparing the results of the logfile based QA and that of measurement-based QA.

METHOD

All treatment plans were delivered in 1.5T Unity MR-Linac (Elekta, Stockholm, Sweden). A Unity compatible version of LinacView (Standard Imaging, Middleton, WI) was commissioned to automatically monitor and analyze the log files. A total of 66 fields were delivered and measured by ArcCheck®-MR (Sun Nuclear, Melbourne, FL) and LinacView. Eleven incorrectly matched fields were also delivered to check for error detection sensitivity. The gamma¹, γ , with 3%, 3 mm criteria was used in both ArcCheck®-MR and LinacView. Additionally, the gantry angle, jaws, and multi-leaf collimators (MLC) positions reported in the log file were compared with plan positions using TG-142 criteria².

RESULTS

The γ (3%, 3mm) for the 55 correct plans were found to be [94.7%, 100.0%] and [95.4%, 100.0%] for ArcCheck®-MR and LinacView respectively. All the delivered gantry angle and jaws were found to be within 0.2° and 2mm. Figure 1a shows an example of gamma analysis, γ , of a single field measured with ArcCheck®-MR with γ (3%, 3mm) of 100%. The corresponding intensity map analysis generated by the log file captured and analyzed with LinacView with γ (3%, 3mm) of 99.6% (Figure 1b). Figure 1(c) and (d) show the analysis of an incorrectly matched plan delivery with ArcCheck®-MR and LinacView with significant lower γ score of 84.8% and 21.7% respectively. Both systems were able detect incorrectly matched plan delivery.

In addition to fluence comparison, LinacView is capable to detect the MLC positions deviation from the plan positions of all the MLCs. Some of the MLC may not be captured by ArcCheck®-MR due to insufficient photon fluence. In particular, MLCs that were outside the guard leaves or under the diaphragms were found to have more than 1.0 mm discrepancy. Figure 2 shows an MLC leaf deviation of more than 30 mm (in red circle). This is attributed to the linac MLC controller overriding the treatment plan position for closed leaves parked under the diaphragm³. No dosimetry impact on the plan was found. Similar override, with smaller deviations in the order of mm, was also found for leaves parked under the X-jaws. Excluding these discrepancies, all MLC positions were found to be within 1.0 mm. The γ (3%, 3 mm) for the 11 incorrectly matched fields were found to be [3.9%, 84.8%] and [1.2%, 21.7%] for ArcCheck®-MR and LinacView respectively. The overall ranked-correlation between them was found to be 86.0% with p-value<0.01.

In addition, PSQA measurements for online ART can only be performed after treatment. The log file analysis can provide higher throughput due to automation, but can also provide faster PSQA feedback to clinicians and physicists.

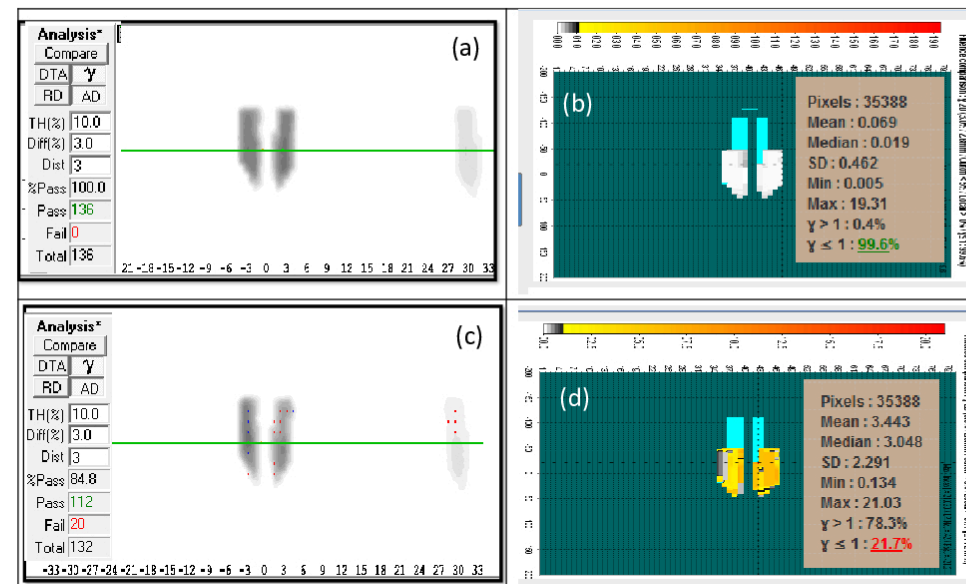


Figure 1: (a) ArcCheck®-MR analysis and (b) log file fluence analysis from LinacView of a typical delivery with comparable (100% and 99.6%) g passing rate; Incorrect delivered plan measured with (c) ArcCheck®-MR and (d) LinacView with significant lower passing rate of 84.8% and 21.7%.

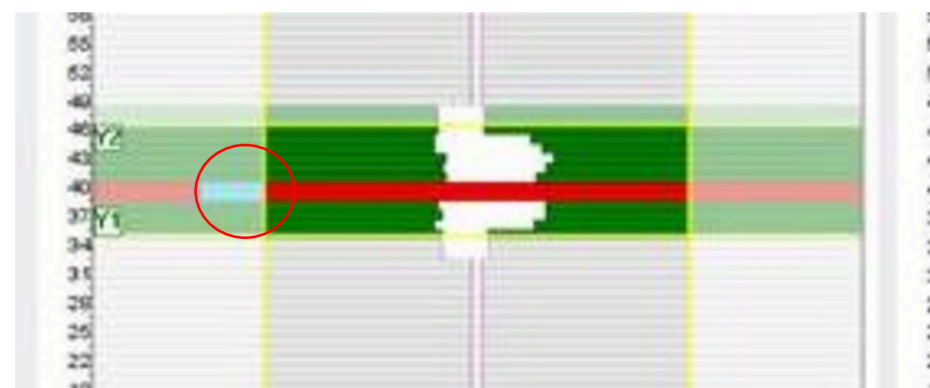


Figure 2: A snapshot of an IMRT step-and-shoot delivery that captures number 40 of MLC leaves with more than 30 mm deviation (shown in red circle). Number 40 leaf pair was flagged as failed. This is attributed to the linac MLC controller overriding the treatment plan position.

CONCLUSIONS

Significant ranked-correlation demonstrates the automated logfile analysis can be used for PSQA and expedite the ART workflow. Ongoing PSQA will be compared with logfile analysis to investigate the longer-term reproducibility and correlation. The log file analysis not only can provide higher throughput due to automation, but can also provide faster PSQA feedback to clinicians and physicists.

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