Automated Film-Based Quality Assurance Framework for Elekta Unity MLC Position Verification Using Stakitt Test

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INTRODUCTION

The portal-based picket fence (PF) test is a commonly used assessment of MLC position accuracy on modern linear accelerators [1]. While the Elekta Unity MR-Linac can utilize its MV imaging panel to routinely perform the PF test, the size of the EPID (22cm x 9.5cm, 265.6cm SID) limits the evaluation to the center 30 MLC pairs, less than half of the total number of MLCs on the system. In recent years, researchers have explored two alternative methods to determine leaf position accuracy, log-file based analyses [2] and film-based measurements [3]. This work proposes an automated framework improving upon existing film-based tests to empirically monitor MLCs by adding lateral comb patterns onto a traditional PF test for indexing MLC leaf pairs.

METHOD

An elongated film strip was created by joining three Gafchromic RTQA2 sheets, providing coverage for 73 of the 80 Unity MLCs. The film was placed at isocenter (143.5cm SAD) between two 2-mm sheets of copper to address electron return effects and minimize Lorentz Force impact on secondary electrons. A modified PF test, named stakitt [4], was performed on the film using 5 central pickets of 0.5cm width spaced 2cm apart alongside two lateral comb patterns. Individual MLCs were identified using the comb patterns and the central MLCs were marked by elongated teeth.

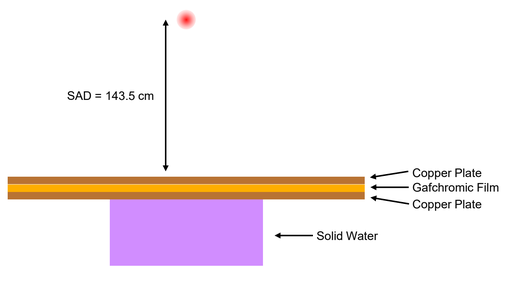

Figure 1:Schematic of elongated film setup, placed between two copper plates at 143.5cm SAD, sitting ontop of 13cm of solid water.

An in-house python script registered and analyzed films to determine MLC leaf gap positions using a single scan of the full strip. Results were compared to a routine PF test of the central 30 MLCs using an onboard electronic portal imaging device (EPID). The detection algorithm's sensitivity was validated by digitally introducing a controlled 1-mm error.

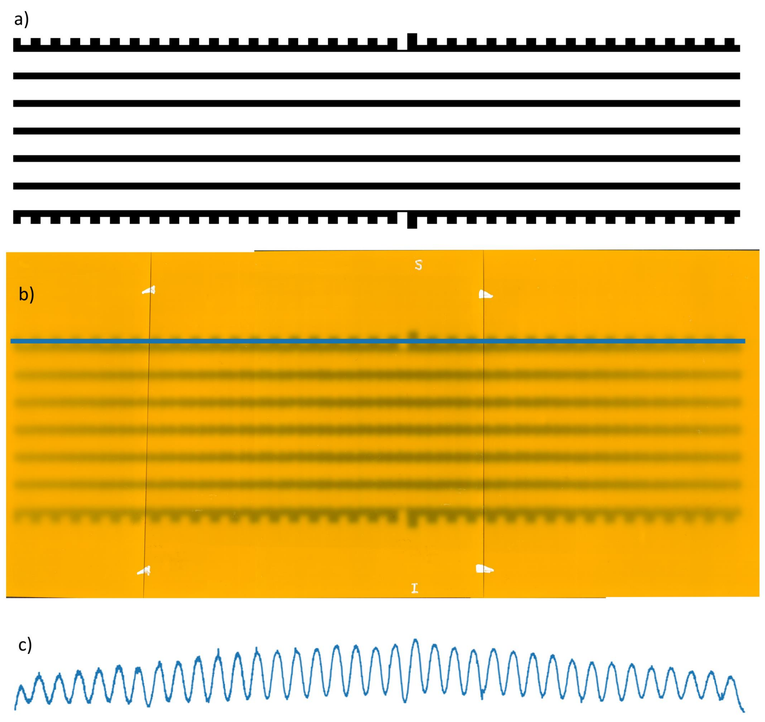

Figure 2: Visual representation of modified PF pattern with five central lines alongside two comb patterns (a), an exposed film strip receiving a 250 MU delivery of the stakitt test (b) with horizontal line plotting relative intensity of the comb pattern profile (c).

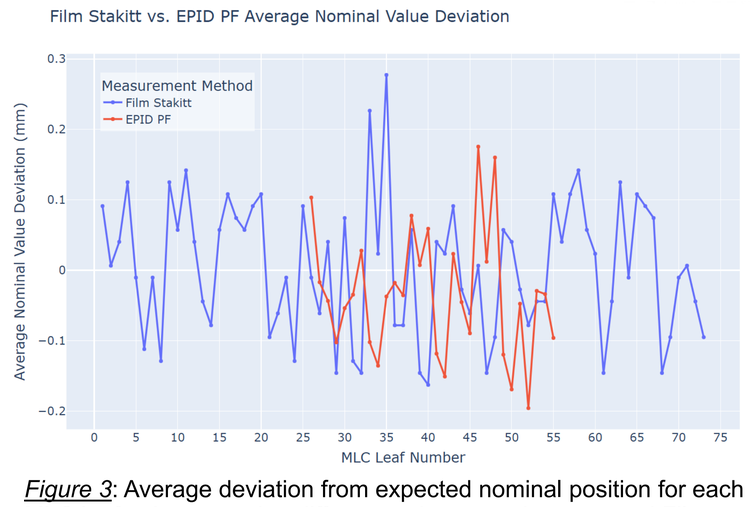

Figure 3: Average deviation from expected nominal position for each MLC leaf pair, comparing differences between the proposed Film Stakitt analysis of MLC leaf pairs 1-74 (blue), and the EPID based PF test analyzing MLC leaf pairs 26-55 (red).

RESULTS

The mean absolute error (MAE) and maximum leaf error detected using a 250 MU stakitt delivery and automated analysis were 0.09±0.07mm and 0.33mm respectively, both within an institutional tolerance of 0.5mm of expected values. These values agree with a PF test of the central 30 MLCs obtained via EPID (MAE = 0.05±0.03mm, maximum = 0.19mm). The deliberate 1mm shift in MLC positions was detected within 0.03mm of its expected position and appropriately flagged.

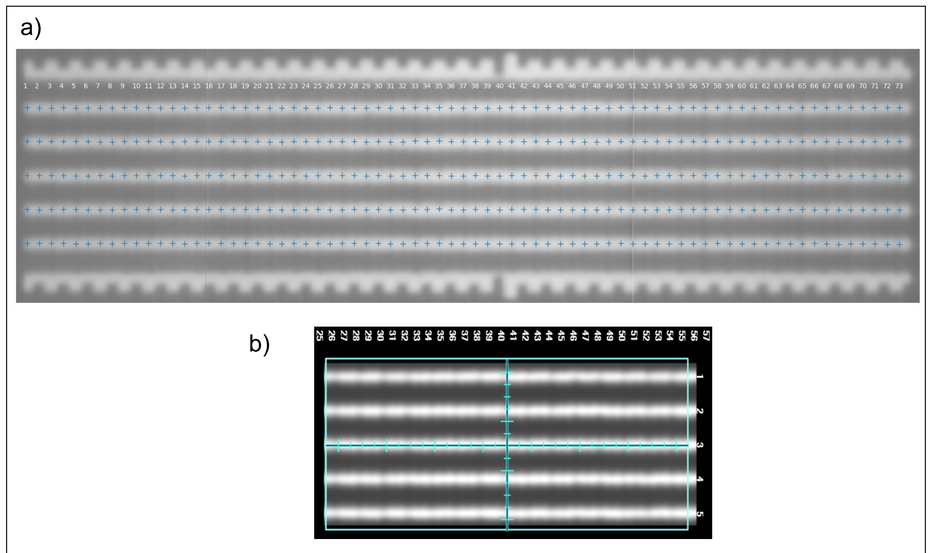

Figure 4: Output of stakitt analysis on exposed film and positions marked with "+" (a) along with corresponding SNC SunCheck analysis for EPID-based PF of central 30 MLCs (b).

CONCLUSIONS

The film-based stakitt procedure addresses PF difficulties inherent to the Unity system by evaluating MLCs outside of the EPID's field of view and using the test's signature comb pattern to aid in leaf identification. Altogether, the procedure allows for the routine and efficient quality assurance of MLC positional accuracy on the Unity MR-Linac.

REFERENCES

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