2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING
MEDICAL PHYSICS COMMUNITY INSPIRATION INNOVATION IMPACT

A Trajectory Log-Based Approach to Fraction-Specific Quality Assurance

Authors, J. Pence[1], S. Cradick[1], J. Mikell[1], T. Sudlow[1], Y. Wu[1], J. Hansen[1], Z. Saleh[1], P. Wall[1], N. Knutson[1], M. Schmidt[1]

[1]WashU Medicine, St. Louis, MO

SITEMAN CANCER CENTER

WashU Medicine | BJC HealthCare

INTRODUCTION

Modern linear accelerators produce trajectory log files (TLF) containing delivery parameters during external beam radiotherapy treatment; TrajectoryLog.net simulated multi-leaf collimator (MLC) leaf-position deviations including systemic leaf openings, shifts, skews, and backlash through TLF modification. The treatment TLFs were analyzed using a commercial phantom-less patient-specific quality assurance (PSQA) platform. TLF analysis of quality assurance plans is currently performed routinely before treatment occurs and after each treated fraction.

AIM

Using Radformation Clearcalc software, multiple fraction TLFs were used as input into the RadMonteCarlo dose calculation platform and compared against the dose from treatment planning system. Minor leaf-position errors were introduced into the TLFs to determine the impact of leaf position error upon the RadMonteCarlo dose calculation analysis.

METHODS

- Trajectory log files of 20 multi-fraction treatment courses were collected from 2 TrueBeam Linear Accelerators featuring HD MLC and standard Millenium MLC.
- A custom-developed C# script (TrajectoryLog.net) modified the TLFs to simulate wear-related MLC errors such as 0.5mm systemic opening (error in MLC Gap), 0.5mm systemic shift (centerline error), -0.5/0.5mm skew (angular misalignment), and 1mm backlash (delay in linear movement of MLC).
- Radformation's Clearcalc V2.6.5 RadMonteCarlo software calculated 3D gamma analyses for the original and modified TLFs at a 2%/2mm criteria and a 10% threshold.

RESULTS

RadMonteCarlo (RMC) software successfully detected simulated errors within external beam radiotherapy trajectory log files (TLFs) when compared against treatment plan control points and unmodified TLFs [Figure 1]. As shown in Fig. 2 error introduction yielded distinct average 3D gamma pass rate decreases for backlash (0.595%), skew (0.0640%), systemic shift (2.36%), and systemic opening (3.65%). Fig. 3 indicates unmodified 3D gamma pass rate ranges of [90.2-100], backlash [85.8, 100], skew [90.1, 100], systemic shift [55.0, 100], and systemic opening [74.1, 99.97].

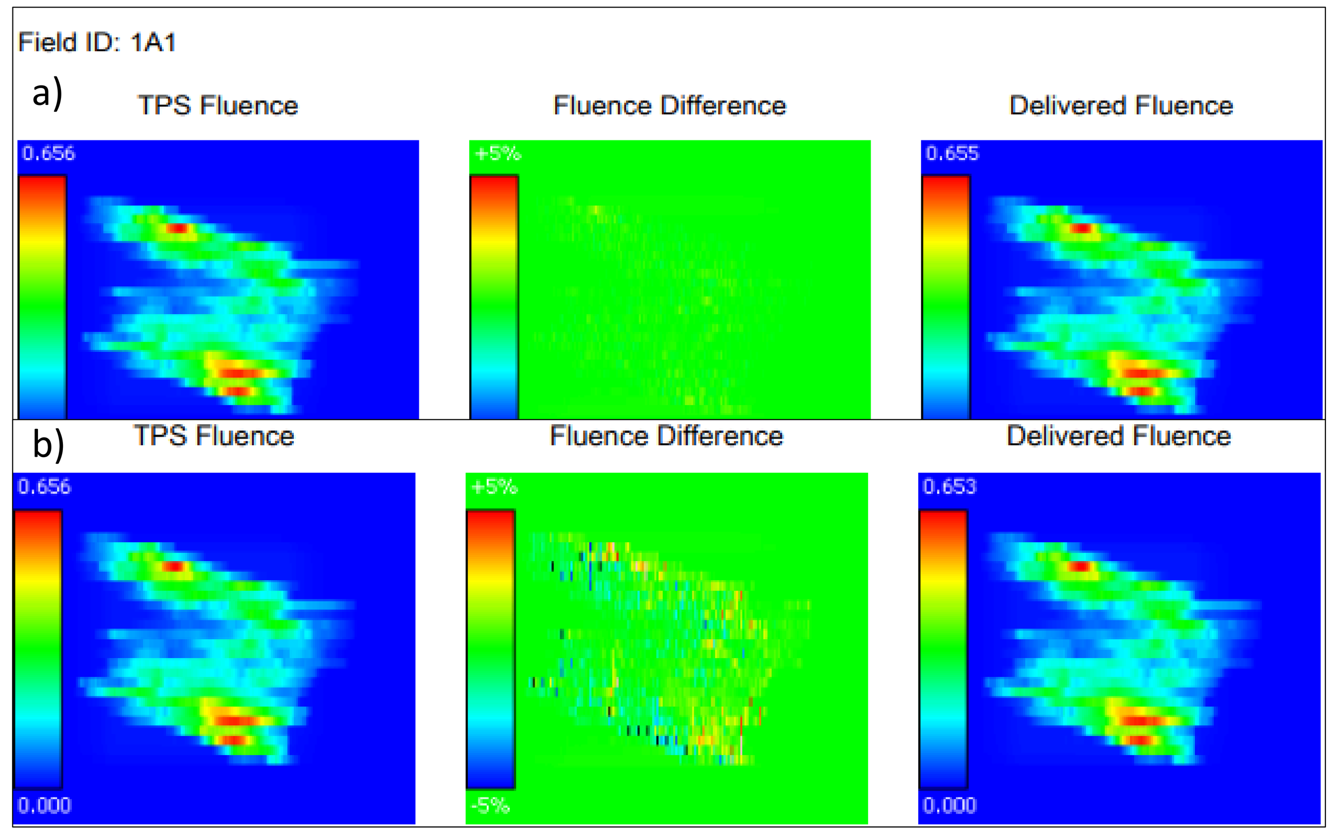

Figure 1: Log file fluence difference (5% threshold) depicted using RMC software; Both rows depict the fluence difference between TPS and delivery, (a) visualizes the unmodified field (b) visualizes a modified field (0.5mm systemic shift) with a greater fluence difference.

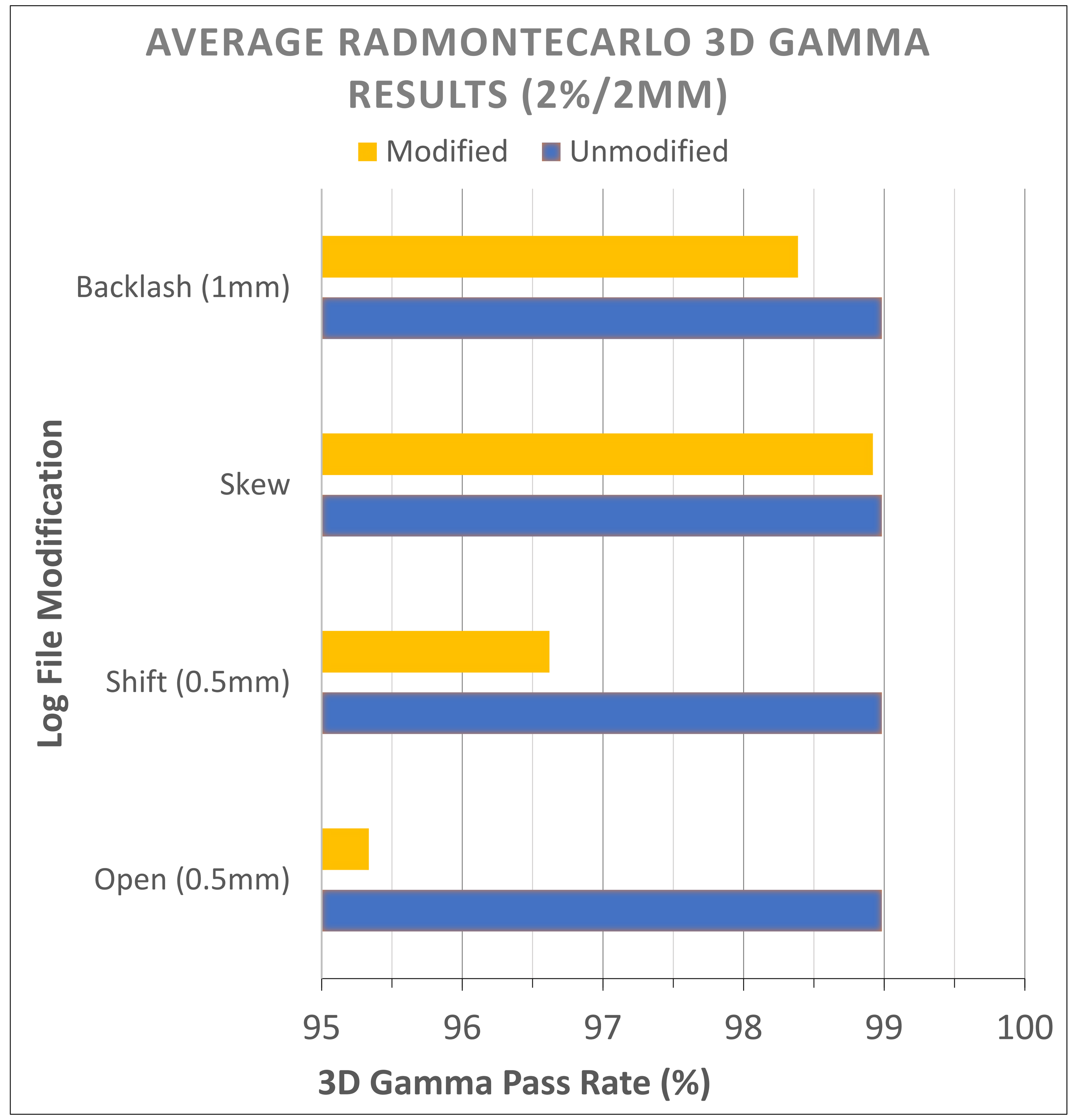

Figure 2: Average 3D gamma results of all simulated-error plans (yellow) compared to the analysis of the original unmodified (blue).

INDIVIDUAL 3D GAMMA ANALYSIS RESULTS

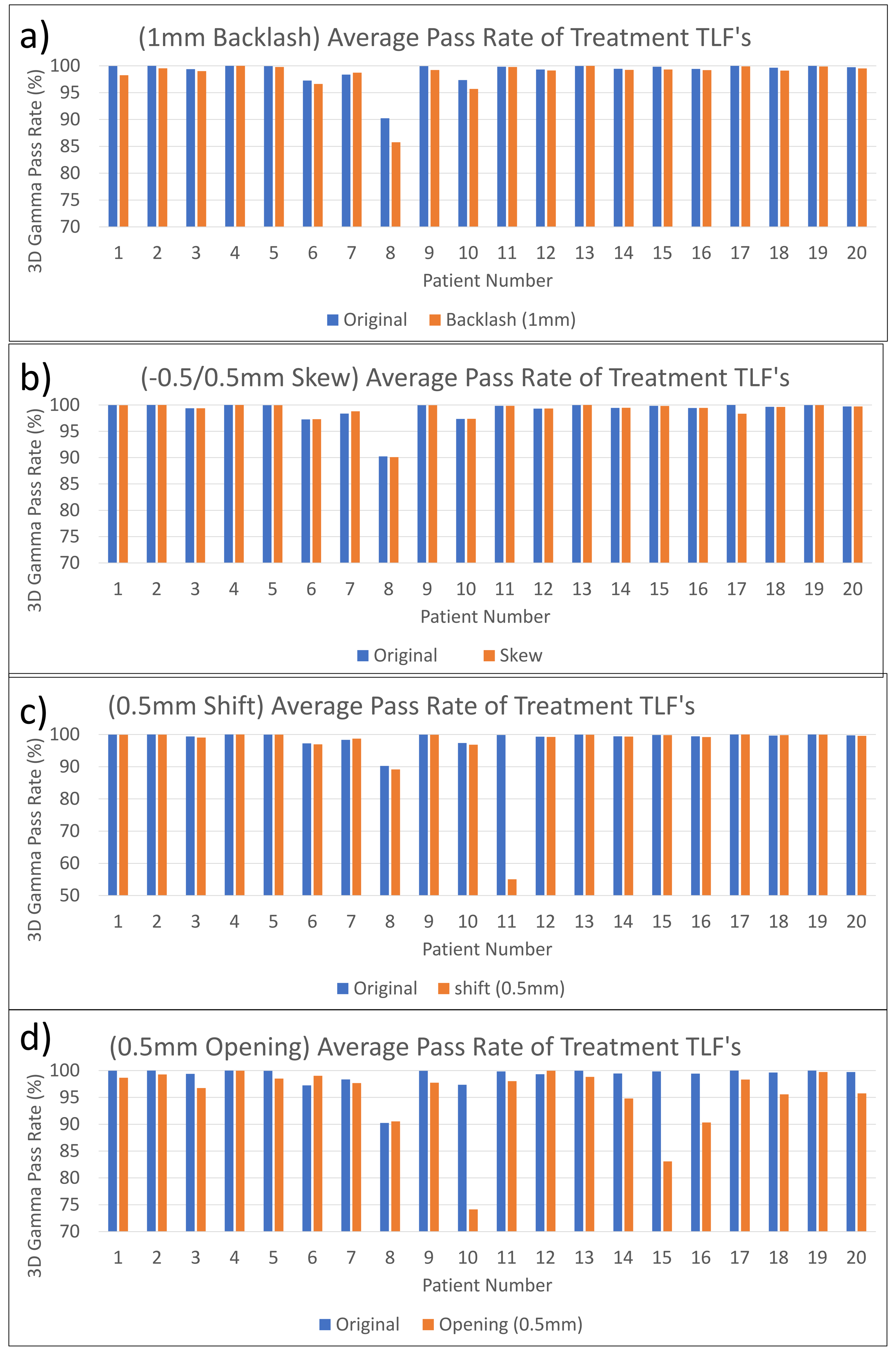

*Figure 3: **3D gamma pass rate comparison between unmodified and modified TLFs for 20 multifraction treatments (2–10 fractions per patient).** Bar plots display the 3D gamma analysis pass rates (%) evaluated using 2%/2 mm criteria with a 10% threshold. Unmodified deliveries compared against simulated delivery errors: (**a**) 1mm MLC backlash, (**b**) -0.5/0.5mm MLC skew, (**c**) 0.5 mm MLC shift, and (**d**) 0.5 mm MLC opening.*

ACKNOWLEDGEMENTS

Radformation engineering and support teams.

WashU QA team for delivering PSQA for these plans.

CONTACTS

Matthew C. Schmidt; Matthew.schmidt@wustl.edu

Jonathan C. Pence; Pence@wustl.edu

CONCLUSION

Sensitivity validation of Radformation's commercial software shows daily auditing of treatment trajectory log files can assist in detection of divergent plan delivery parameters. Integration of an RMC-guided workflow can be used to detect plan deviations that can develop from mechanical wear during treatment and flag them for physicist review.

REFERENCES

Wall P, et al. Clinical validation of statistical predictive model for patient-specific quality assurance outcomes in stereotactic radiotherapy using secondary Monte Carlo dose calculations. Radiother Oncol. 2025 Jul;208:110934. doi: 10.1016/j.radonc.2025.110934. Epub 2025 May 11. PMID: 40360048.

Schmidt M, et al. TrajectoryLog.Net: Applications of an Integrated Trajectory Log File Analysis API. XXth International Conference on the use of Computers in Radiation Therapy. 2024.

@WashUMedRadOnc