

Winston-Lutz Test on the True Beam Linear Accelerator using PTW ruby Phantom.

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OBJECTIVE

In linear accelerator-based stereotactic radiosurgery (SRS) and stereotactic body radiotherapy (SBRT), single-isocenter treatment of multiple metastases has become increasingly popular because of its high treatment efficiency and reduced treatment time. However, the lack of a comprehensive quality assurance (QA) program remains a challenge for medical physicists.

METHODS

The Winston-Lutz test, which we developed six years ago, was performed on a True Beam linear accelerator (Varian Medical Systems). Treatment beams were designed using the Eclipse treatment planning system with full gantry, collimator, and couch rotations. All beams were delivered using a PTW RUBY phantom. Portal images were acquired using the on-board electronic portal-imaging device (EPID) of the True Beam linear accelerator and analyzed directly using PTW isoCheck EPID software. This study also aims to predict isocentric stability for stereotactic body radiation therapy (SBRT) treatments using machine learning (ML), covers the challenges of manual assessment and computational time for quality assurance (QA), and supports medical physicists to enhance accuracy. Five ML models, including logistic regression (LR), decision tree (DT), random forest (RF), naive Bayes (NB), and support vector machines (SVM), were used to predict the outcome of the QA procedure.

RESULTS

Measured deviations

Parameter	Average measured deviation (mm)
Gantry	0.72
Collimator	0.63
Couch	0.46

All measured values were within 1 mm.

MACHINE LEARNING RESULTS

In our study, both DT and RF achieved the highest score on test accuracy (Acc. test) ranging from 93.5% to 99.4%, and area under curve (AUC) values from 90 to 100% on three modes (C, G, and T). The precision, recall, and F1 scores indicate the DT model consistently outperforms other ML models in predicting isocenter stability deviation in QA.

DATA SET & ML QA PROCEDURE

WL Tests	247
Train Set	185 (75%)
Test Set	62 (25%)
Cross-validation	4 fold
Evaluation metrics	Recall • Precision • F1 score • AUC-ROC • ACC
ML Models	LR • DT • RF • NB • SVM

CONCLUSION

To the best of our knowledge, this is the first reported isocenter Winston-Lutz test performed using a PTW RUBY phantom on a True Beam linear accelerator. The results demonstrate that the measured isocenter deviations for the gantry, collimator, and couch were within 1 mm, indicating good geometric accuracy and supporting the use of this approach as part of the QA program for SRS and SBRT treatments.

KEY WORDS

stereotactic radio surgery (SRS), stereotactic body radiotherapy (SBRT), linear accelerator and Winston-Lutz test.

QA DATA COLLECTION & MACHINE LEARNING QA PROCEDURE

