Validation of a Software Module to Verify the Fidelity of Arc Plan Delivery in Real Time

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Introduction

The use of transmission detectors to monitor the accuracy of the delivered fluence has become more common over the past few years with the release of several commercial devices. Our group has previously investigated[1] the error detection capabilities of one such device, the Discover from Scandidos.

While our previous investigations have confirmed that the Discover could detect errors on the order of 1 mm in MLC leaf mispositioning, as well as as mistakes in gantry and collimator positions, the results are currently only presented at the end of each field or arc. While feedback on the fidelity of delivery per field or arc can allow for beam interruption before the completion of a fraction for multi-field/arc plans, it would ideal if any detected error was reported as soon as it was identified.

This work evaluates the effectiveness of newly available, *real-time* software capability for the ScandiDos Discover transmission detector in detecting fidelity of arc-based treatment deliveries.

Methods

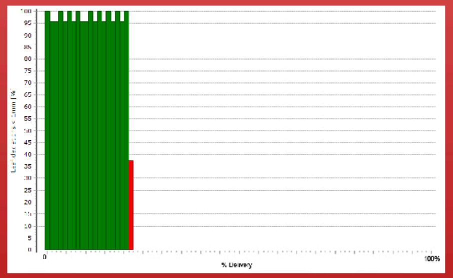
A non-clinically-released alpha software was used to evaluate the ability of the Discover system to detect plan delivery errors instantaneously, versus the current software's ability to detect and report errors at the end of a delivered field/arc. Towards this end, a dynamic conformal arc plan was created as a baseline plan. This plan was imported into the ScandiDos test software as the 'expected' plan.

In-house software was then used to systematically introduce 5 mm errors in all MLC leaf positions at different points within the arc. Errors in collimator and gantry positions were also introduced in other iterations of the plan. These altered plans were then delivered with the Discover device mounted to the linear accelerator. The ability of the new real-time software to accurately detect errors instantaneously was evaluated.

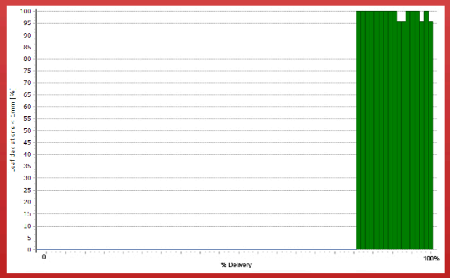
Results

A user customizable tolerance level for leaf position accuracy was set to a requirement of at least 90% of leaves being within 1 mm of their intended position. During the measurement, a bar graph shows the percentage of leaves meeting the specified requirement. For all of the simulated known-error scenarios, the software correctly detected and accurately indicated the time point when the leaves became out of tolerance. The system also correctly identified the timepoint when the gantry and collimator became mis-positioned.

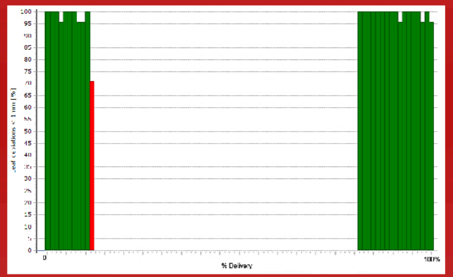
The figure below shows screenshots from the software module when different errors were intentionally introduced to the plans prior to delivery. The legend below each figure describes the discrepancy introduced.



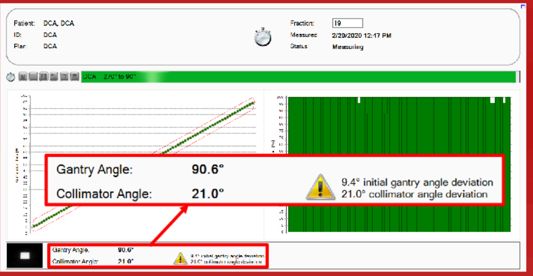
Leaves shifted 5 mm after 20% of field was delivered.



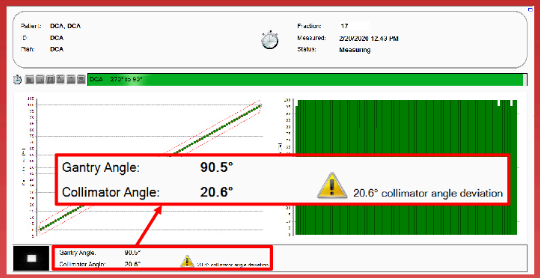
Leaves shifted 5 mm for the first 80% of the field and then returned to original plan location.



Leaves shifted 5 mm after 10% of the field was delivered and returned to planned position once 80% of the field was delivered.



Gantry and collimator at the wrong angle for the start of the beam.



Collimator set at incorrect angle.

Gantry set at wrong angle at the start of the beam, thus requiring a back-track to the correct starting position.

Conclusion

It was confirmed that the new software module can be used to provide essentially instantaneous, real-time feedback of the position of the MLC leaves, gantry and collimator during the delivery of an arc plan. This real-time feedback can allow the user to immediately interrupt treatment delivery for error prevention and further investigation.

References

[1] Sarkar, Vikren, et al. "A systematic evaluation of the error detection abilities of a new diode transmission detector." Journal of applied clinical medical physics (2019).