Characterization of clinically released ScandiDos Discover diode array for in-vivo dose monitoring

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Introduction

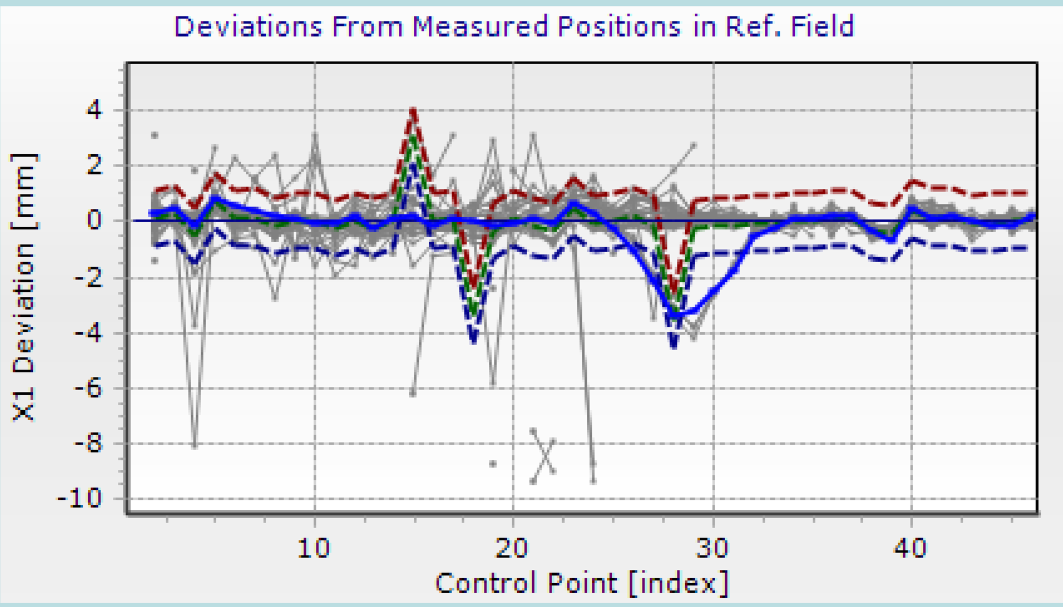
The Scandidos Discover has obtained FDA clearance and is now clinically released. We studied the essential attenuation and beam hardening components as well as tested the diode array's ability to detect changes in dose per fraction and leaf positions.

The Scandidos Discovery is currently being marketed as an independent in-vivo dosimeter. The radiation therapy community can greatly benefit from a baseline characterization of how the device impacts the clinical beam as well as its ability to detect the sorts of changes it is designed for.

Methods and Materials

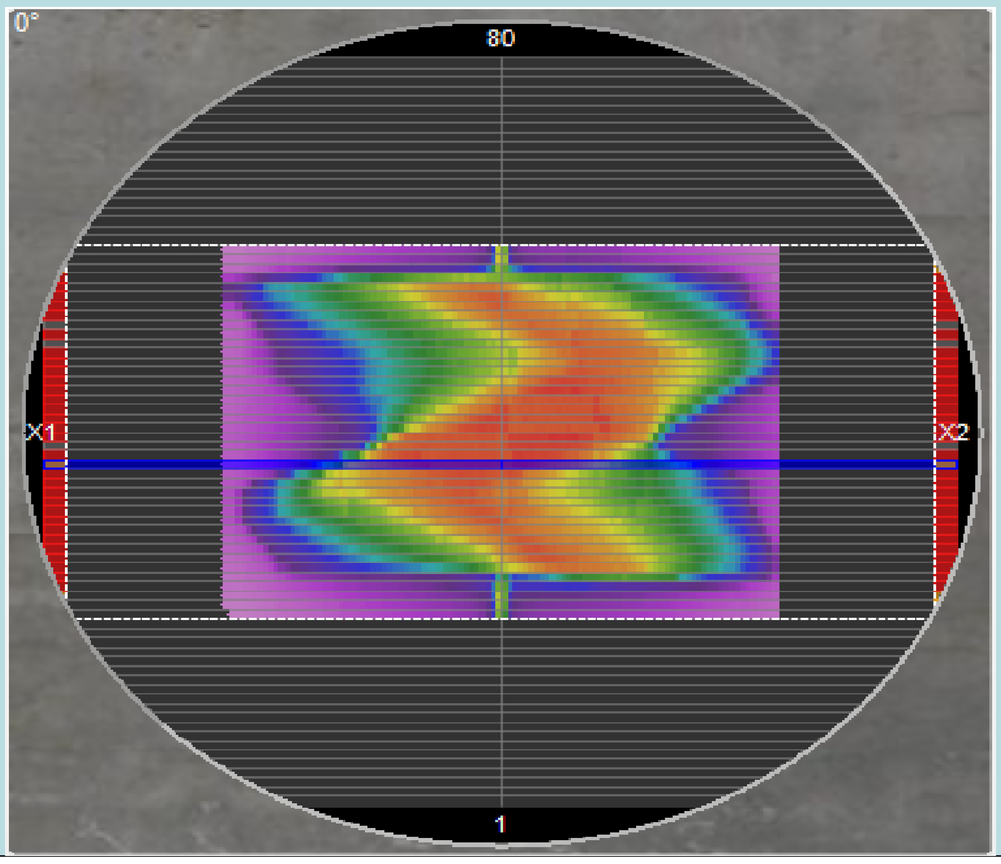
The Scandidos Discover was mounted on the heads of an Elekta VersaHD and a Varian 23EX. Attenuation measurements were made at 10 cm depth for 6 MV and 18 MV beam energies. The PDD(10) was measured as a metric for the effect on beam quality. Next, a plan consisting of two orthogonal 10 x 10 cm2 fields was used to adjust the dose per fraction by scaling monitor units to test the sensitivity of the Discover. A second plan was then delivered on the Elekta VersaHD consisting of a conformal arc with artificially introduced MLC position errors in the four central leaves. The errors were incrementally increased from 1 mm to 4 mm and back across seven control points.

The vendor's calibration protocol to cross-calibrate the diodes, ensure alignment of the Discover with the head, and calibrate the leaf edges was first followed.



The position of each MLC leaf can be monitored either relative to the DICOM RTPLAN position or relative to a pre-treatment reference field (from pre-treatment IMRT QA for example).

Fluence per control point can be visualized. The position of the 50% fluence along an MLC leaf path is used as an estimate of the leaf position. Complications include incidental measurement of signal from an adjacent MLC leaf opening caused by misalignment of the detector board with the linear accelerator coordinate system.



Results

Attenuation and beam hardening:

The measured attenuation is within a half of a percent of what the vendor quotes as 1%, while the hardening caused by the device is minimal. The attenuation and hardening is summarized in Table 1. Attenuation depended slightly on the field size but only changed the attenuation by 0.1% across 5 x 5 and 20 x 20 cm^2 fields.

	6 MV	18 MV
Attenuation (% decrease in dose at 10 cm)	-1.2%	+0.1%
Beam Hardening (% change in PDD(10)	-0.7%	+0.6%

Table 1: Attenuation and beam hardening results.

Dose Linearity:

Changes in monitor units from -5% to 5% were faithfully detected. Detected leaf errors were within a millimeter of actual errors.

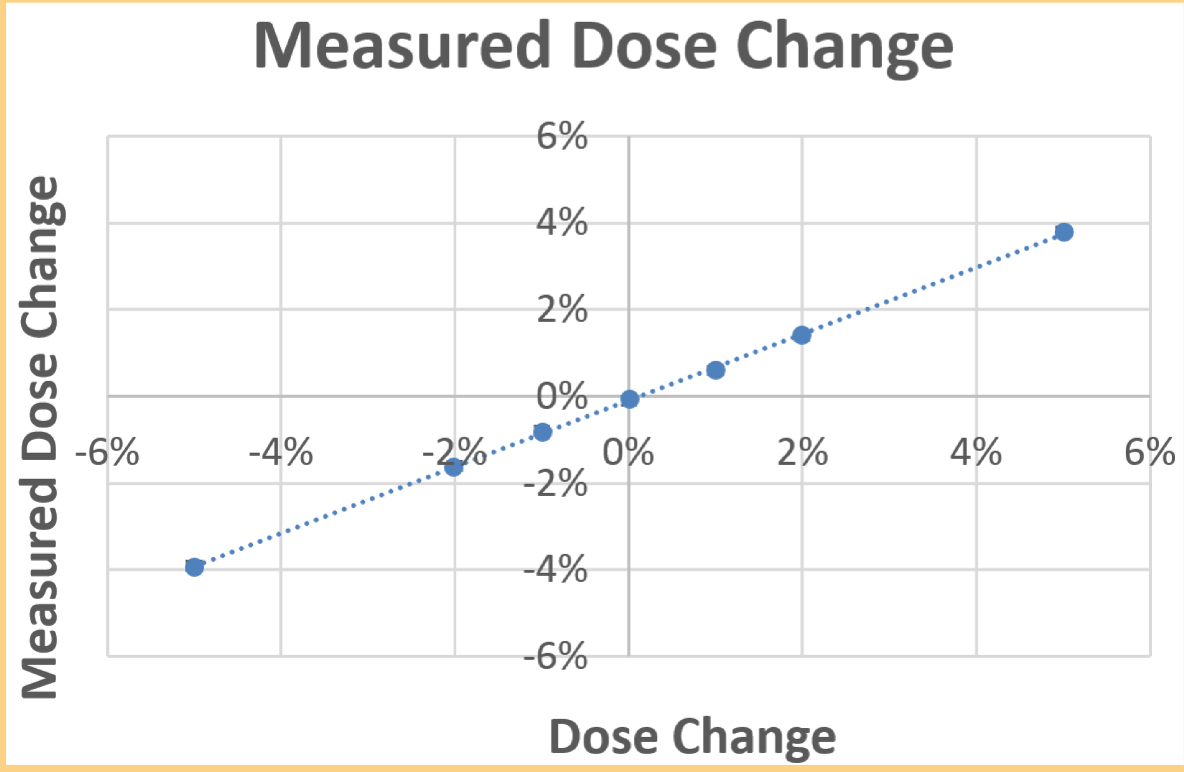


Figure 2: Response of Delta4 Discovery to changes in dose (from scaling monitor units).

Leaf Error Detection:

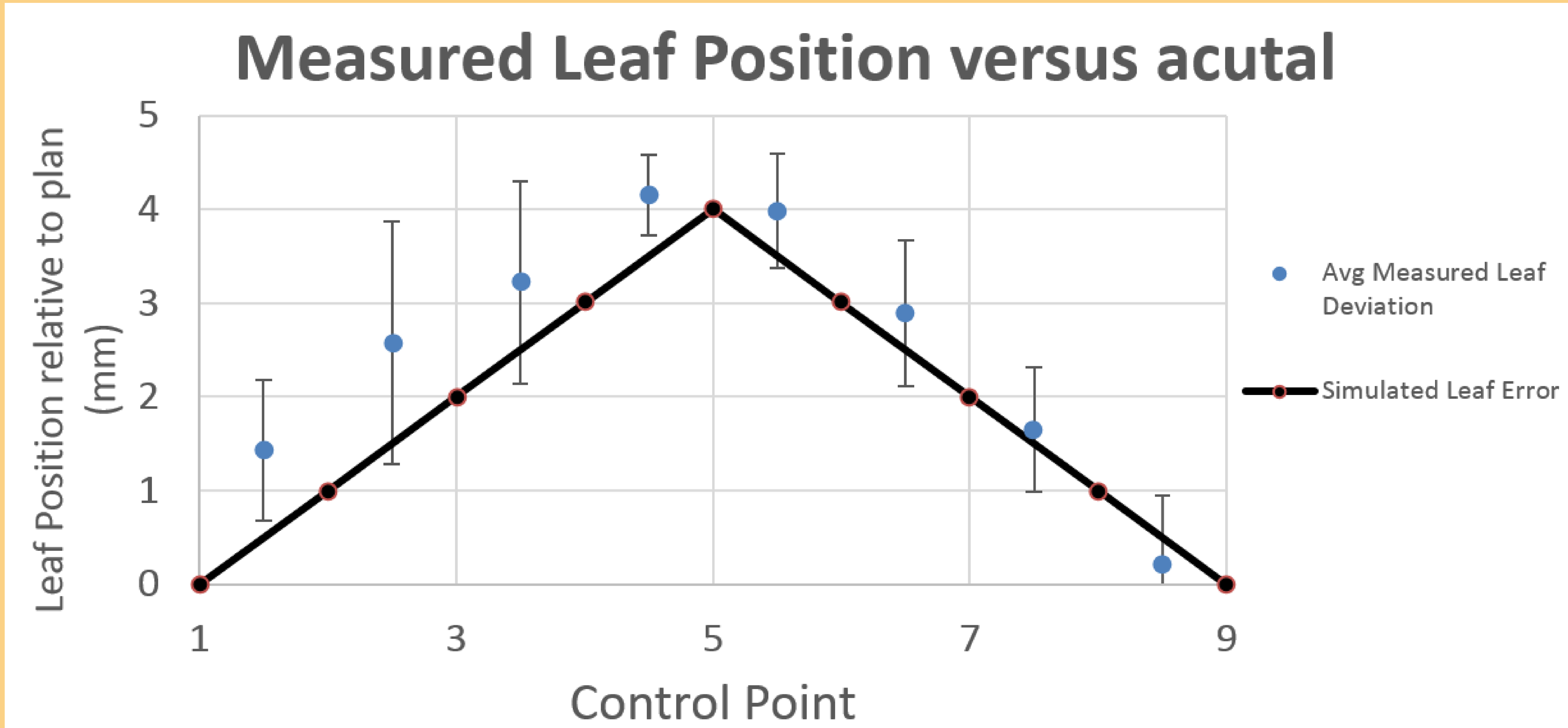


Figure 3: Tracking of simulated MLC leaf errors. Across 9 control points, a leaf was forced to go to positions 1-4 mm from the originally planned positions. The errors increased then decreased in magnitude over the 9 control points.

- The ability to measure a change in dose exhibited a slight under-response (Figure 2), but the linearity is excellent across the range of doses used.
- The detection of leaf errors was somewhat complicated by the fact that a measurement for a given control point happens between two control points, effectively measuring at the midway point between control points.
- The measured leaf positions where more "in-phase" with the simulated errors for control points 6-9 than for control points 1-5 suggesting that measurement may not take place exactly halfway between control points.

Conclusion

A novel in-vivo dosimeter which monitors the radiation beam during treatment was examined through its attenuation and beam hardening characteristics. The device tracked with changes in dose per fraction as well as introduced leaf position deviations.

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