JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
Improving Health QUALITY. Increasing Global IMPACT

DETERMINATION OFF-AXIS DOSIMETRIC LEAF GAP USING OPTICALLY STIMULATED LUMINESCENCE DOSIMETERS AND AN ELECTRONIC PORTAL IMAGING DEVICE

TIMOTHY P B SANTOSH[1], J DIVYALAKSHMI[1], K M MOHAMATHU RAFIC[1], A SEBASTIN, J SUJITH CHRISTOPHER and J SOLOMON RAJ
DEPARTMENT OF RADIATION ONCOLOGY, CHRISTIAN MEDICAL COLLEGE, VELLORE, INDIA

INTRODUCTION

- Accuracy of sophisticated RT techniques such as IMRT and VMAT is directly dependent on
  - the accurate geometric modelling and
  - incorporation of dosimetric characteristics of the dynamic MLCs.
- The dosimetric leaf gap (DLG)
  - accounts for rounded leaf-end transmission in the dose calculation algorithm of the treatment planning system (TPS)
  - incorporated into the TPS which models the leaf-end as "square" in the optimization algorithm.
- *Current limitation of commercial-available TPS* : Global modelling of the leaf-end transmission with a single DLG value measured at central axis (CAX) (1).

AIM

- To investigate the dosimetric feasibility of using OSLD and an EPID for off-axis (OAX) DLG measurement
- To develop a strategy to overcome the low-dose under-response of the EPID and
- To generate a 2D-EPID-based DLG map to accurately depict the adjacent leaf pair-specific DLG and its OAX variation across the field.

METHOD

- A ten-field "DLG plan" was computed on the Eclipse™ TPS (Varian Medical Systems, Palo Alto)
  - A reference open field and two completely blocked MLC fields and
  - Seven sweeping fields of gap widths ranging from 2 to 20 mm.
- The Clinac 2100C/D linear accelerator equipped with the Millennium-120 Multileaf collimator (MLC) and aS1000 EPID was utilized.
- The DLG measurements were performed at CAX and ±1 cm OAX (superior and inferior positions) with each measurement covering two 5 mm-adjacent leaf pairs using nanoDot™ OSLD (Landauer, Inc., Glenwood, IL) and validated using ionization chamber dosimetry (ICD) using a Semiflex chamber (PTW, Freiburg, Germany).
- The DLG was determined for the "zero millimetre" field width using the linear extrapolation method (2).
- The DLG was obtained from the graph in which the output factor (OF) corrected for MLC transmission (MLCT) is plotted against its corresponding sweeping gap width (w) using a combined formula (Eq. 1) from equations described in literature (3,4).

$$OF_{w,i,j} = \frac{D_{w,i,j} - D_{MLCT,i,j}\left(1-\frac{w}{L}\right)}{D_{ref,i,j}} \quad \text{Eq. 1}$$

2D DLG_{EPID} map:

- The two-dimensional DLG map (2D DLG_{EPID}) was derived from the portal images of the DLG plan using a custom-developed software script as shown in Fig. 1.
- The script also incorporated sliding aperture-specific correction factors (Eq. 2) to correct for the under-response of the EPID.

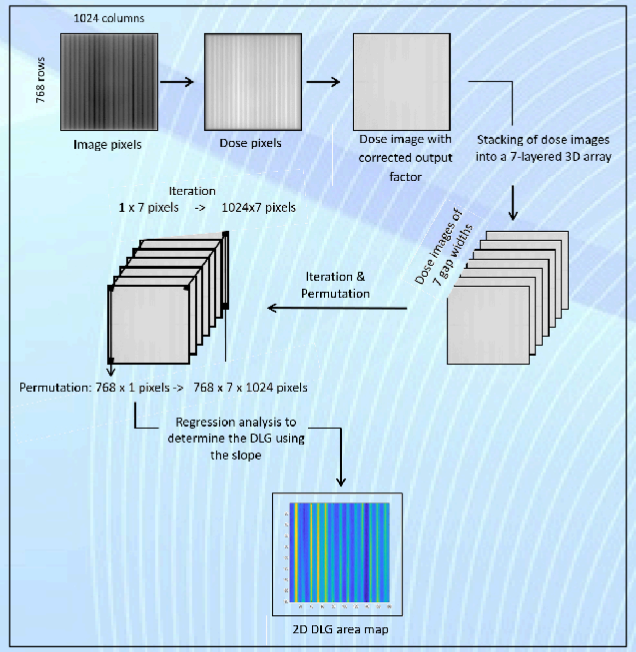

Fig. 1. A workflow algorithm illustrating the generation of a 2D DLG map from the portal images of the EPID

$$\delta_{EPID,w} = \frac{R_{ICD,w}}{R_{EPID,w}} \quad \text{Eq. 2}$$

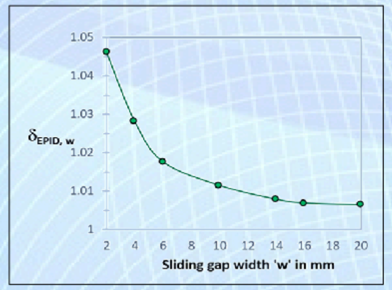

Fig. 2. Sliding aperture-specific EPID response correction

RESULTS

- It was found that the DLG_{ICD} and DLG_{OSLD} at CAX were similar (≤1%) to that measured at inferior OAX position while the same at superior OAX position differed by ≥20% showing that DLG varied across the field.
- The relative dose responses of the EPID ($R_{EPID\,w}$) and the ICD ($R_{ICD\,w}$) were found to vary from 4.6% to 0.6% as the sliding gap width increased from 2 mm to 20 mm respectively, as illustrated in Fig. 2 the EPID response was corrected as per Eq. 2.

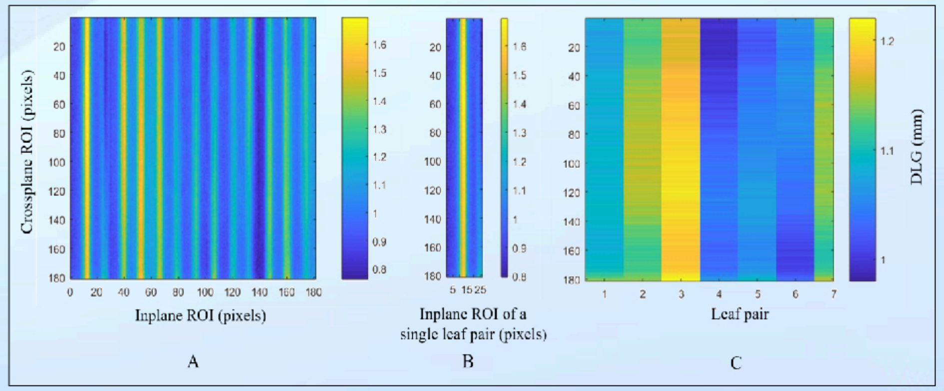

Fig. 3. Analysis of the 2D DLG map

A) The central 7 x 7 cm^2 (180 x 180 pixels) region of the 2D DLG map selected for analysis
B) An adjacent leaf pair (width of 26 pixels) consisting of two adjoining MLC leaves (blue regions) that encompass an inter-leaf region in between (yellow region)
C) The 2D map portraying the averaged leaf pair-specific DLG values across the field. The 3rd, 4th and 5th leaf pairs correspond to the superior, central and inferior leaf pairs.

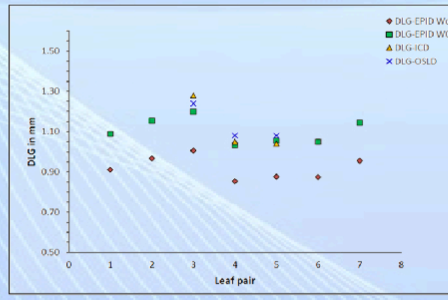

Fig. 4. Leaf pair-specific DLG values obtained from 2D DLG_{EPID} map, OSLD & ICD
DLG-EPID WCF & DLG-EPID WoCF: DLG_{EPID} with and without correction factors
3rd, 4th & 5th MLC leaf pairs correspond to superior, central and inferior leaf pairs

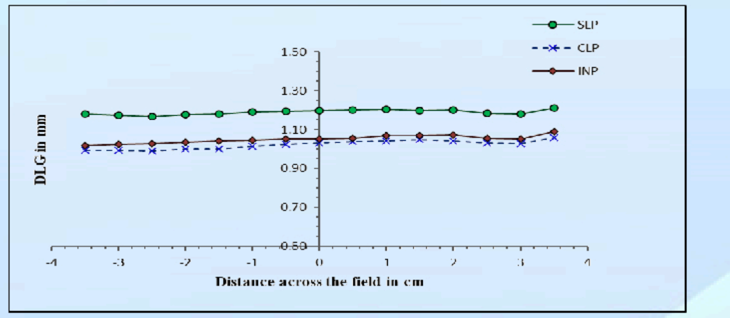

Fig. 5. DLG_{EPID} profile across the field for CAX & ±1 cm OAX leaf pairs
SLP: Superior leaf pair CLP: Central leaf pair INP: Inferior leaf pair

- The central 7 x 7 cm^2 region of 2D DLG_{EPID} map was evaluated by generating profiles averaged over each adjacent leaf pair as shown in Fig. 3.
- The corresponding DLG_{EPID} values derived using aperture specific correction were found to be in good agreement with DLG_{OSLD} and DLG_{ICD} (Fig. 4).
- The analysis of the DLG_{EPID} values across the field (Fig. 4) showed that DLG was different for each adjacent leaf pair.
- The analysis of the DLG_{EPID} profiles taken along each adjacent leaf pair (Fig. 5) also showed substantial variation in the mean DLG values of each leaf pair at off axis positions.
- The 2D DLG_{EPID} map lends insight into the varying patterns of the DLG with respect to each leaf pair at any position across the field.

CONCLUSIONS

- Commensurate results of DLG_{OSLD} with DLG_{ICD} values have proven the efficacy of OSLD as an apposite dosimeter for DLG measurement.
- The under-estimation of DLG values due to the inherent limitation of EPID in the low dose ranges has been successfully addressed by the novel perception of using appropriate aperture-specific correction.
- The 2D DLG_{EPID} map opens a potential pathway to accurately model rounded-leaf end transmission with discrete leaf-specific DLG values in a 2D dose space.

REFERENCES

1. Kumaraswamy LK, Schmitt JD, Bailey DW, Xu ZZ, Podgorsak MB. Spatial variation of dosimetric leaf gap and its impact on dose delivery. Med Phys 2014;41:111711-*1-8*.
2. LoSasso T, Chui C-S, Ling CC. Physical and dosimetric aspects of a multileaf collimation system used in the dynamic mode for implementing intensity modulated radiotherapy. *Med Phys 1998;25:1919–27.*
3. Mei X, Nygren I, Villarreal-Barajas JE. On the use of the MLC dosimetric leaf gap as a quality control tool for accurate dynamic IMRT delivery. Med Phys 2011;38:2246–55.
4. Balasingh STP, Singh IRR, Rafic KM, Babu SES, Ravindran BP. Determination of dosimetric leaf gap using amorphous silicon electronic portal imaging device and its influence on intensity modulated radiotherapy dose delivery. *J Med Phys. 2015;40(3):129–135.*

ACKNOWLEDGEMENTS

This work was supported by an internal Fluid Research Grant (FG/9307/2/2015) from Christian Medical College, Vellore

CONTACT INFORMATION

Timothy P B Santosh: timothy@cmcvellore.ac.in