Imaging the effective point of measurement of a dosimeter inside a phantom

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INTRODUCTION

The Leksell Gamma Knife (LGK) solid water (SW) phantom is designed for the PTW 31010 ionization chamber for reference dosimetry (Fig 1). When this phantom is used, **effective point of measurement (EPM)** of other detectors does not coincide with the EPM of PTW 31010. In this study, we developed a simple and effective method to determine the EPM of a detector inside the existing LGK-SW phantom.

AIM

To develop an **imaging method** for identifying the **EPM** of a detector inside a **LGK -SW dosimetry phantom**.

METHOD

- When the PTW-31010 is inserted into LGK-SW phantom, the EPM is at (x,y,z) = **(100,100,100)** of Leksell Coordinate System (LCS), which might not be same for other detectors, particularly in the *z*-direction.
- A strategy was developed for identifying the ***z*-LCS coordinate** of EPM for four diode detectors (Table 1) using the **CBCT of Gamma Knife Icon unit.**
- CBCT image was acquired for each detector and the flat face/tip of the detector was identified. The *z*-LCS coordinate of **EPM** was then determined based on the **published distance between EPM and the flat face/tip**.
- For validation, a plan was generated to measure the output of 4-mm collimator for PTW-TN60017 at various z-locations.

RESULTS

- Fig 2 illustrates how z_{eff} was determined for the CBCT scan of PTW-60019. In Fig2, z-LCS coordinate of the detector tip was identified to be z = 96.5. Since EPM of this detector is 1.3 mm from the tip, the exact EPM location was z_{eff} = 96.5 + 1.3 = 97.8, or 2.5 mm from the EPM of PTW-31010.
- Applying the similar calculation, z-LCS coordinate was at z_{eff} = 98.5, 98.9, and 97.5 for respectively PTW-TN60008, TN60016, and TN60019.
- Fig 3 shows the relative output profile along the z direction, measured using the PTW-TN60017 diode. The 50% relative output (green box) occurs at z=95.2 mm and 100.2 mm, so the center of the measured profile was located at z = 97.7, only **0.1 mm difference** from z_{eff} = 97.8 for this diode identified using the CBCT method.

Detector	Sensitive Volume (mm^3)	Reference point from Tip (mm)	z- LCS of EPM (mm)
PTW TN60008	0.03	2.0	98.5
PTW TN60016	0.03	2.4	98.9
PTW TN60017	0.03	1.3	97.8
PTW 60019	0.004	1.0	97.5

Table 1: Characteristics of the four diode detectors used in this study. The last column lists the z - LCS of EPM when it is inserted into the SW phantom, derived using the CBCT method.

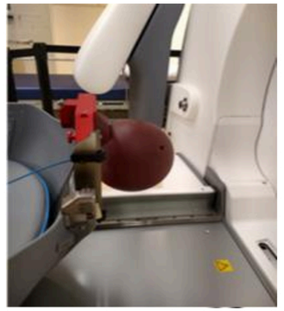

Fig 1. Setup for the verification of EPM of different diode detectors in a LGK-SW.

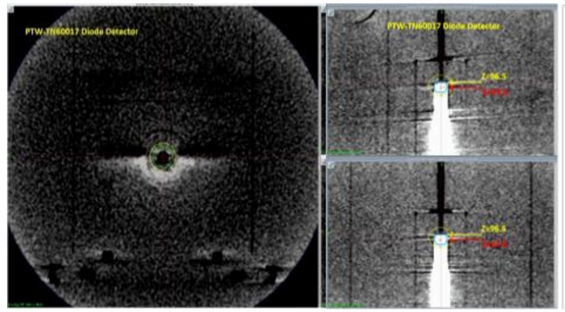

Fig 2. CBCT images for PTW 60019: (a) axial, (b) sagittal and (c) coronal view. As shown in (b) and (c), z = 96.5 (mm) is the z-LCS of the tip of detector in the superior-inferior (S-I) direction. Since the EPM is 1 mm inferior from the tip for this diode, z_{eff} = 96.5 + 1.3 = 97.8 (mm) is the Z LCS of EPM.

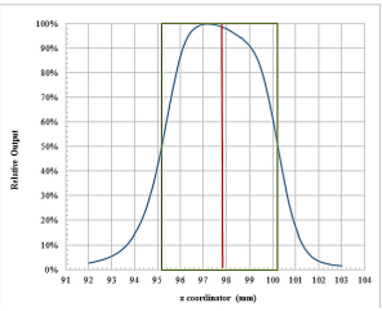

Fig 3. The 50% relative output (green box) occurs at z = 95.2 and 100.2, so the center of the profile is located at (95.2 + 100.2) / 2 = 97.7, which is 0.1 mm different from the identified location (zeff = 97.8, red line) of the sensitive volume for this diode.

CONCLUSIONS

- A **simple** and **effective method** was developed to determine the EPM of diode detectors inside the holder of LGK -SW phantom designed for PTW 31010 ion chamber.
- With the acquired information, **each diode can be positioned at the focal point of the machine** for accurate relative dosimetry measurements, without any modification or customization of the LGK SW phantom.

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