Virtual cone commissioning with Polymer Gel Dosimetry (PGD)

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Purpose

Treatment of Trigeminal Neuralgia can be accomplished by using a novel stereotactic radiosurgery (SRS) method, called the virtual cone technique. In this work, we built an in-house eclipse script to implement this technique based on a previous work by The University of Alabama, Birmingham[1]. A novel Polymer Gel Dosimetry (PGD) with cone-beam computed tomography (CBCT) readout was implemented to commission this novel technique.

Introduction

Trigeminal Neuralgia is typically treated with surgery or radiotherapy, using Gamma Knife, Cyberknife or a linac with physical stereotactic cones. Gamma knife and Cyberknife are not regularly available in many centers. Physical cone require cone-specific dose calculation algorithms and additional commissioning and quality assurance. To mitigate these challenges, a virtual cone technique was implemented utilizing a High-Definition Multi-leaf collimator (MLC) to produce a small spherical dose of 80 Gy at the isocenter.

In this work, polymer gel dosimetry with CBCT readout and EBT3 film were used to commission this SRS technique. CBCT offers unparalleled spatial accuracy over other gel readout methods such as MRI and CT.

Materials

We used a NIPAM-based gel recipe, which comprised of 15% N-isopropylacrylamide (NIPAM, Sigma Aldrich, Mississauga ON, Canada), 4.5% N,N'-methylenebisacrylamide (Sigma), 5% 300 bloom gelatin (Sigma), 10 mM, tetrakis(hydroxymethyl)phosphonium chloride (THPC, Sigma), and 75.5% deionized water. EBT3 film was used for film measurement.

Methods

Multiple MLC leaf gaps were investigated in this work. One gel measurement and 2 EBT film measurements (sagittal, coronal) were acquired for each leaf gap. The isodose width at 50% of the maximum dose was measured by plotting the dose profile along crossline, inline, beam central axis directions.

Results and Discussion

The leaf gap of 1.4 mm resulted in a 50% isodose width closest to a 5 mm physical stereotactic cone. Table 1 presents the width measurements of 1.4 mm leaf gap in terms of mm.

Conclusions

In this work, we successfully presented the efficacy of using PGD with CBCT readout in commissioning a complex virtual cone SRS technique.

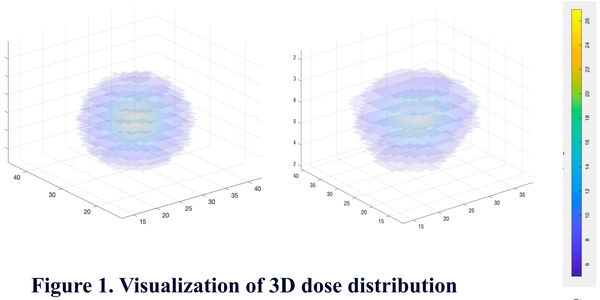

Figure 1. Visualization of 3D dose distribution

Left: Eclipse, right: Gel dosimeter

References

1.) Popple, R.A et al. The virtual cone: A novel technique to generate spherical dose distributions using a multileaf collimator and standardized control point sequence for small target radiation surgery. Adv. Radiat. Oncol. 3, 421 - 430 (2018).

2.) Jirasek, A. et al. Linac-integrated kV-cone beam CT polymer gel dosimetry. Phys. Med. Biol. 65, 225030 (2020).

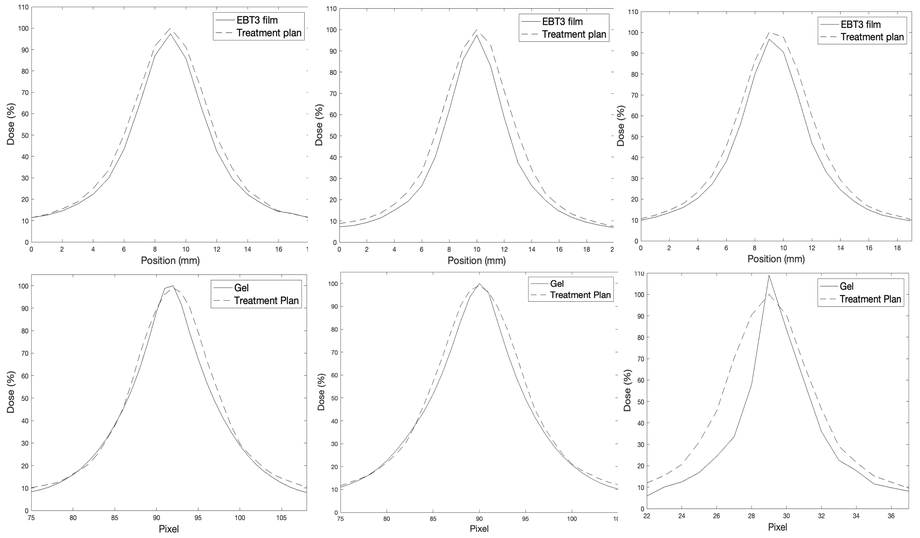

Figure 2. Line profiles along crossline, inline, beam central axis directions

The dose profile along crossline, inline, beam central axis directions in both the NIPAM gel dosimeter and EBT3 film is shown below. Figure 1 (top) shows the dose profile across the EBT3 film dosimeter and (bottom) shows the dose profile across gel dosimeter.

MLC leaf gap (1.4 mm)	Crossline (mm)	Inline (mm)	Beam Central axis (mm)	Mean (mm)
Eclipse	5.69	5.68	5.54	5.64
Gel	5.20	5.08	4.63	**4.97**

MLC leaf gap (1.4 mm)	Crossline (mm)	Inline (mm)	Beam Central axis (mm)	Mean (mm)
Eclipse	5.88	6.00	5.98	5.95
EBT3	5.22	4.87	4.91	**5.00**

Table 1. *The mean gel dosimeter measurement of 50% isodose width, across crossline, inline, beam central axis directions was within 0.03 of the EBT3 film measurement. The limitation of using CBCT as gel readout is the resolution of the z-axis is limited to only 1 mm (see figure 1).*

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