2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

Dosimetric Considerations in Clinical Implementation of a 3D Print Material for Patient-Specific Hybrid Intracavitary/Interstitial Gynecologic High-Dose-Rate Brachytherapy Cylinders

Devin Van Elburg, PhD[1]; Niki Moideen, MD[1]; Michael Lamey, PhD[1]; Michael Kudla, PhD[2]; Deidre Batchelar, PhD[2], Claire Foottit, PhD[1].
[1]The Ottawa Hospital, Ottawa, ON; [2]BC Cancer, Kelowna, BC.

PURPOSE

To determine the dosimetric impact of 3D-printed patient-specific clinical templates (PSCTs) printed with Formlabs Biomed Clear (BC) resin in gynecologic (GYN) high-dose-rate brachytherapy (HDRBT), and to validate clinical intuition of typical cases that would benefit from PSCTs versus vaginal multichannel cylinders (VMCs), for the purpose of clinical implementation.

INTRODUCTION

Gynecologic (GYN) interstitial high-dose-rate brachytherapy (HDRBT) implants are complex procedures that require considerable expertise and appropriate image guidance techniques to achieve high quality implants. Recently, Kudla *et al.*[1] developed a workflow using 3D printed patient specific cylindrical templates (PSCTs) which are customized to the patient anatomy, considerably simplifying the implant process.

Towards clinical implementation, this work summarizes two dosimetric investigations related to PSCTs: 1) What impact does the 3D print material have on the dosimetry in a TG-43 dose calculation workflow, and 2) which patients would benefit from treatment with PSCTs versus current standard applicators such as the vaginal multichannel cylinder (VMC)?

METHODS AND MATERIALS

Resin Dosimetry: A single channel cylinder was 3D printed with Biomed Clear (BC) resin (1.09 g/cm^3) to dimensionally match a clinical 3cm diameter vaginal vault cylinder (Elekta) made of PPSU (1.30g/cm^3). Five uniformly weighted dwell positions with 1cm spacing was delivered through the PSCT, the vaginal cylinder, and water. Dose was measured using GafChromic EBT3 film placed in a large water tank at 5mm, 10mm, and 20mm depths. Planned dose was 300cGy to each depth.

Planning Benefit of PSCT: PSCT treatment plans in Oncentra (Elekta) were created following the Kelowna method.[1] A subset of previously treated VMC plans were identified which may benefit from PSCTs due to depth of invasion/lateral extent of the target, and/or organs at risk proximity. Retrospective plans were made by overlaying the PSCT on the VMC in the pre-brachytherapy MRI which mimics the clinical workflow.

CONTACT

Devin Van Elburg
The Ottawa Hospital
501 Smyth Road, Ottawa, ON, K1H 8L6
devan@toh.ca
(613) 716-2953

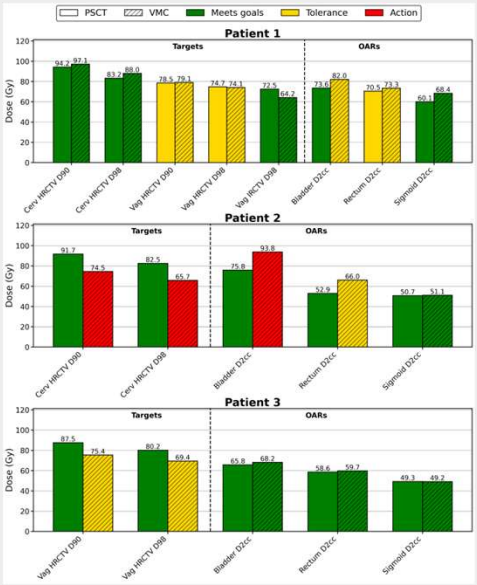

Figure 2a. Dose metrics for the treated VMC plans (hashed bars) compared to retrospectively planned PSCT (solid bars). In all three patients either the target coverage, OAR sparing, or both improve.

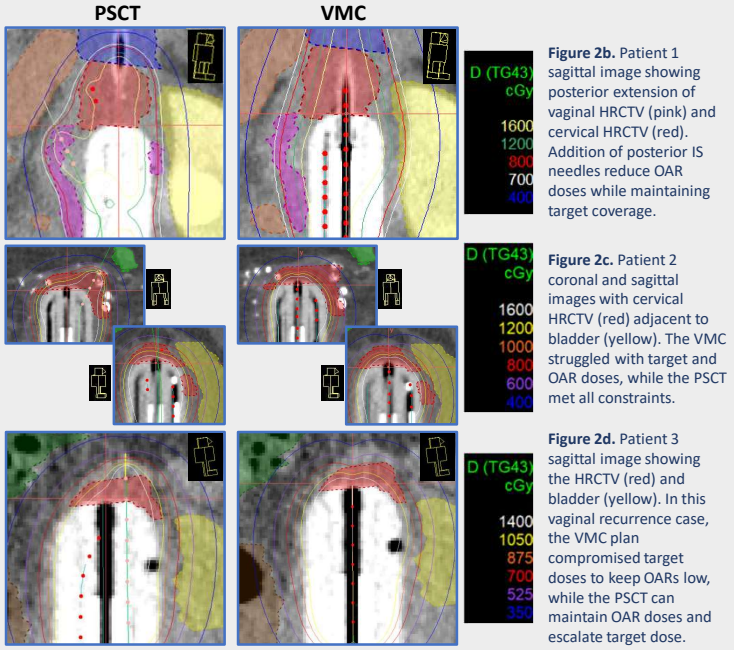

Figure 2b. Patient 1 sagittal image showing posterior extension of vaginal HRCTV (pink) and cervical HRCTV (red). Addition of posterior IS needles reduce OAR doses while maintaining target coverage.

Figure 2c. Patient 2 coronal and sagittal images with cervical HRCTV (red) adjacent to bladder (yellow). The VMC struggled with target and OAR doses, while the PSCT met all constraints.

Figure 2d. Patient 3 sagittal image showing the HRCTV (red) and bladder (yellow). In this vaginal recurrence case, the VMC plan compromised target doses to keep OARs low, while the PSCT can maintain OAR doses and escalate target dose.

RESULTS AND DISCUSSION

Resin Dosimetry: Film doses through each cylinder material is given in Figure 1. Relative to water, the mean ± standard deviation dose difference for BC was -0.8% ± 1.2%, while PPSU was -3.8% ± 1.2%. This shows TG-43 dose calculation for BC-made cylinders is appropriate and does not introduce additional uncertainties compared to the clinical cylinder material PPSU for TG-43 dose calculation.

Planning Benefit of PSCT: Three patients previously treated with the VMC were identified that may benefit from treatment with PSCTs. Target and OAR dose metrics for the PSCT and VMC plans are shown in Figure 1a. Corresponding images are shown in Figure 2b-d, including brief descriptions of each case. In all cases the PSCT plan was superior to the VMC plan, either through improved target coverage, OAR dose reduction, or both.

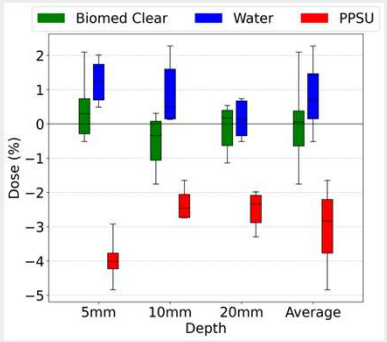

Figure 1. Film doses at 5mm, 10mm, and 20mm depths for dose delivery through 1.5cm of Biomed Clear, water, and PPSU, relative to the 300cGy planned dose. Boxes show the mean and interquartile range, while whiskers show the range.

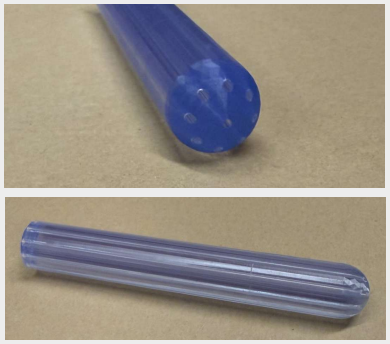

Figure 3. Standard clinical template with one central channel and eight periphery channels, like the VMC but with the added benefit of allowing for straight IS needles to be advanced beyond the cylinder tip.

PSCTs match or outperform the VMC in plan flexibility since the PSCT channel layout can be made like the VMC (i.e. with one central channel and eight periphery channels), except with the added benefit of allowing for advancement of IS needles beyond the cylinder tip (see Figure 3). Starting from this standard clinical template layout, PSCTs can be modified to have patient-specific curved channels to suit the patient anatomy.

PSCTs may also be applied to cervical cases without vaginal involvement. However, retrospective planning studies using PSCTs are challenging for these cases as they are normally treated with applicators such as ring and tandems, which distort the anatomy differently than a vaginal cylinder does.

CONCLUSIONS

It is safe to deliver GYN HDRBT treatments through PSCTs made with Biomed Clear resin since it is a closer dosimetric equivalent match to water compared to PPSU. PSCTs are more dosimetrically flexible than VMCs because of the addition of optimally placed interstitial needles.

REFERENCES

1. Kudla 2023. DOI: 10.1016/j.brachy. 2023.03.002