

Custom cervical brachytherapy applicator compared to commercial applicators: a treatment planning study

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INTRODUCTION

Brachytherapy treatment targets the high-risk CTV (HR-CTV) remaining near the end of EBRT treatment.¹

- Commercial applicators are inflexible for needle positioning and placement in large HR-CTVs.
- A custom 3D printed patient-specific cylinder template (PSCT) customizes needle placement.
- The PSCT have been implemented for vaginal and cervical cancers at BC Cancer Kelowna².

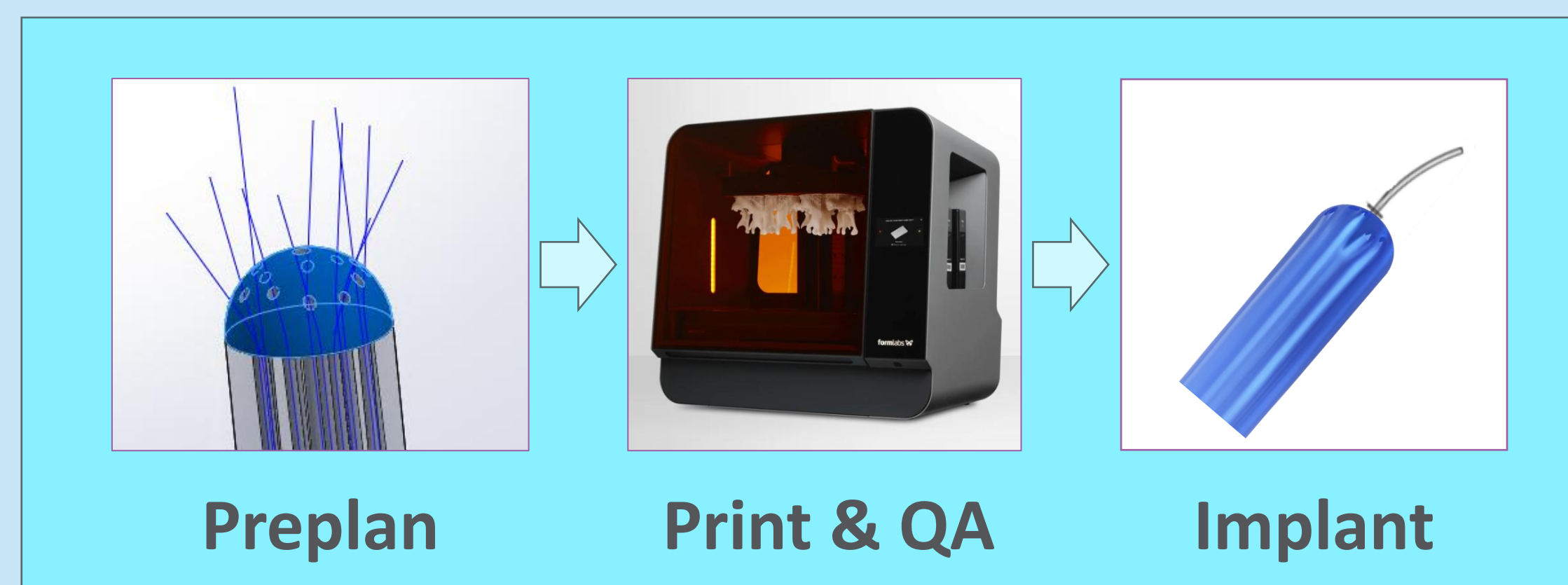


Figure 1. Standard clinical workflow for patient-specific custom templates.



Figure 2. Patient-specific cylinder template (PSCT) sample with needles in place.

METHODS AND MATERIALS

Patient Cohort

High-dose rate (HDR) brachytherapy plans from ten previously treated cervical patients were included.

- Five were treated using tandem and PSCTs.
- Five were treated with Geneva tandem and ovoids.

Applicator Simulation

Applicator models (Oncentra, Elekta) simulated the implant and generate commercial applicator plans.

- Ovoid size and PSCT diameter were selected to match the applicator dimension abutting the cervix.
- The model tandem was aligned to the implant tandem.
- Interstitial needles were digitized along all Geneva and Venezia applicator channels.
- The PSCT needle positions/orientations were designed to cover the high-risk CTV (HRCTV) extent.

Treatment Planning

Treatment plans targeted HR-CTV with 28Gy/4 prescription.

- EQD2 metrics combined HDR and 45Gy/25 EBRT.
- HR CTV D90% and organs-at-risk D2cc were optimized.

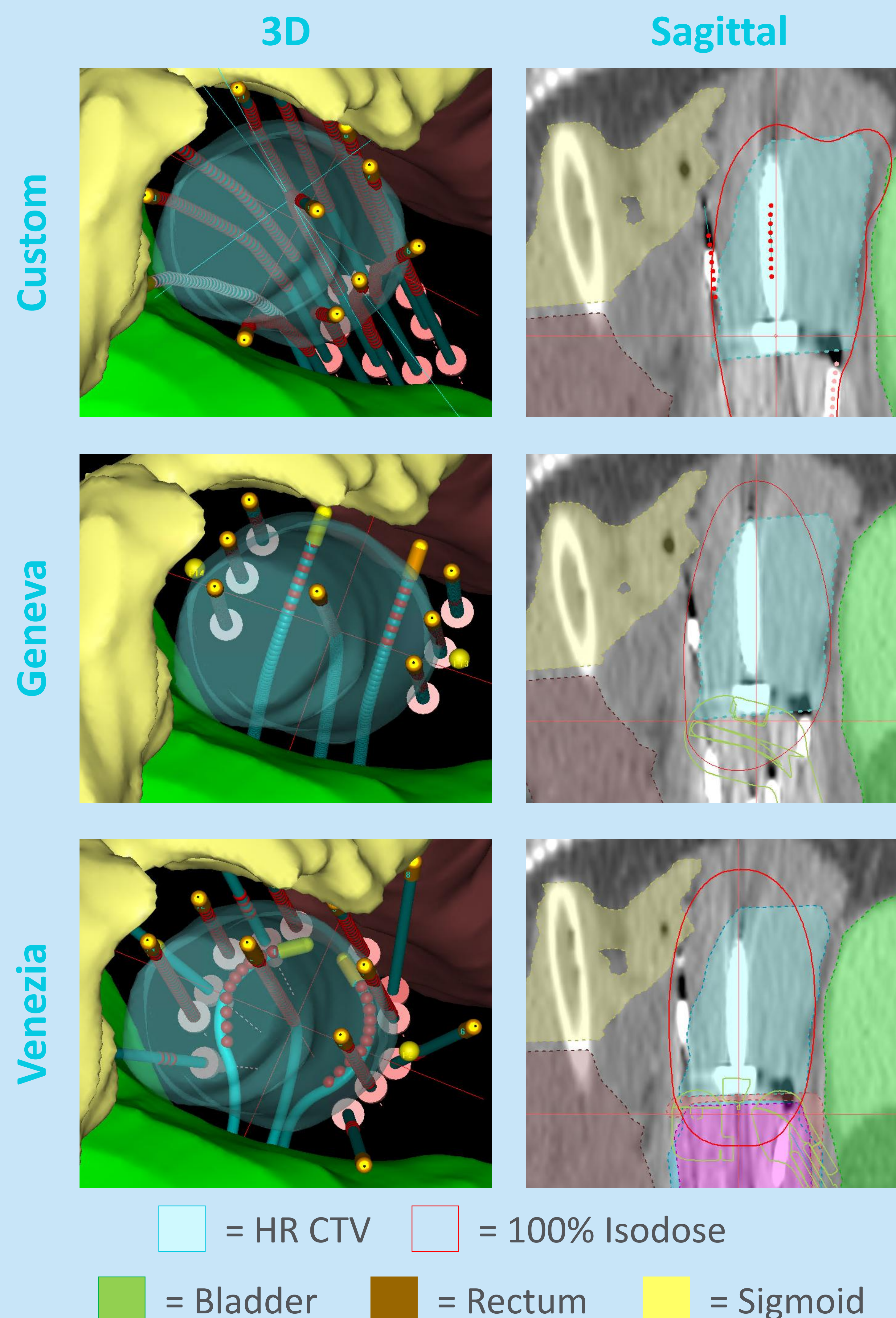


Figure 3. 3D and sagittal view comparing the implant simulation for PSCT, Geneva, and Venezia applicators.

Table 1. EQD2 metrics for each plan accumulated between brachytherapy and 45Gy/25 EBRT treatments.

EQD2 Metric	PSCT median (min-max)	Geneva median (min-max)	Venezia median (min-max)
HRCTV D90% (Gy)	93.9 (90.6-94.7)	94.4 (90.2-95.0)	93.7 (90.6-94.9)
Bladder D2cc (Gy)	74.1 (58.8-85.9)	76.6 (62.5-86.6)	76.0 (61.9-85.9)
Rectum D2cc (Gy)	51.9 (44.6-59.3)	54.7 (44.8-64.9)	54.3 (45.0-61.1)
Sigmoid D2cc (Gy)	59.3 (45.9-64.8)	62.8 (46.5-74.1)	62.8 (45.8-74.2)
Small Bowel D2cc (Gy)	45.4 (43.5-53.4)	45.6 (43.5-54.7)	45.6 (43.5-52.8)

RESULTS

All treatment plans achieved clinically acceptable HRCTV coverage, with most treatment plans meeting the organs-at-risk constraints.

- Organ-at-risk D2cc were statistically lower ($p < 0.05$) in the PSCT plans.
- The PSCT plans activated a higher median ratio of interstitial needles compared to available needles: PSCT = 76 (60-100) %, Geneva = 55 (25-100) %, and Venezia = 44 (25-92) %.
- Figure 3 demonstrates improved needle placement in PSCT implants.
- Table 1 demonstrates the EQD2 for the HRCTV and organ-at-risks.

DISCUSSION

Patient-specific cylindrical templates (PSCT) provide improved needle placement for cervical cancer HR-CTV volume with simulated implants.

- Direct comparison of dosimetry with multiple applicators is challenging, when optimizing implant.
- Our study assumes the deformation at the cervix interface is negligible between implant models.

Needle placement is improved anteriorly and laterally compared to the commercial applicator models.

- Figure 3 demonstrates the improved needle coverage in the anterior portion with the 100% isodose line.
- The Geneva and Venezia applicator model footprints are too wide for the HR-CTV with many needles placed outside the treatment volume.

Improved needle placement, improves the dosimetry!

INNOVATION & IMPACT

Patient-specific custom templates improve anterior HR-CTV needle coverage and reduce the organ-at-risk D2cc doses compared to simulated commercially available applicators.

CONCLUSIONS

Custom 3D-printed PSCTs can treat cervical cancers with improved interstitial needle placement when compared to commercial applicators. The PSCTs:

- Maintain equivalent HR-CTV coverage.
- Reduce OAR D2cc.
- Improve anterior and lateral needle coverage.

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REFERENCES

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