**Background**

**Standard intracavitary vaginal brachytherapy**
- Is delivered with a cylindrical applicator of uniform diameter.
- Optimal dosimetry is achieved with the applicator conforming to the apex to achieve mucosal contact.
- Does not provide adequate dose to irregular vault configurations.

**Alternatives to standard applicators have unique limitations regarding accessibility/personnel and equipment**
- Interstitial brachytherapy requires a skilled clinician to place the catheters, and patient analgesia.
- Conventional vaginal moulds can conform to irregular configurations, but are not amenable to narrow vaginal openings, and do not allow pre-production manipulation and optimization.

**3-D rapid prototyping offers a novel alternative**
- Creates a model of patient anatomy, which can then be evaluated, manipulated, and optimized to create a custom applicator.

**Objectives**

- Explore the clinical use of rapid-prototyping and stereolithographic mould technique to produce a customized vaginal applicator.
- Assess for optimization of brachytherapy dose distribution with a customized applicator.

**Materials & Methods**

**Clinical Case Example**
- Early endometrial cancer and risk factors for local recurrence.
- Irregular vaginal vault with deep ‘dog-ear’ configuration and a wide vaginal apex (4.0 cm) relative to the vaginal introitus (2.5 cm).

**Creation of the 3-Dimensional Image**
- CT simulation with barium contrast-soaked vaginal packing in situ to highlight unique anatomical detail (Figure 1a).
- Packing volume contoured and converted into a 3-dimensional digital surface (Figure 1b).

**Design Considerations**

- Optimize lateral dose dispersion at wide vaginal apex.
- Limit doses to bladder and rectum.
- Facilitate clinical use in placing applicator.

**Custom Applicator Design Concepts**

- 2-part construction, with stable fixation in situ.
- Optimized catheter placement, with the capacity for 3D curvature.
- Alignment dovetail.

**Dosimetric Comparison**

- Improved lateral vaginal dose distribution at the vault: 700 vs 328 cGy (Figure 4).
- Asymmetric dose distribution to right and left vaginal fornices.
- Relative bladder and rectal dose sparing (Figure 5).

**Results**

**Custom Applicator Design Concepts**

- 2-part construction, with stable fixation in situ.
- Optimized catheter placement, with the capacity for 3D curvature.
- Alignment dovetail.

**Dosimetric Comparison**

- The custom applicator was compared to a 2.5 cm standard cylinder using inverse planning with a prescription point at 5 mm depth.

- The custom applicator achieved:
  - Improved lateral vaginal dose distribution at the vault: 700 vs 328 cGy (Figure 4).
  - Asymmetric dose distribution to right and left vaginal fornices.
  - Relative bladder and rectal dose sparing (Figure 5).

**Discussion**

Conventional cylindrical intracavitary brachytherapy applicators do not conform to individual vaginal conformation. Irregular, fibrotic, or tethered tissue result in suboptimal dosimetry when treated with standard applicators. The technique presented here enables the physical creation of a patient specific applicator with embedded optimized catheter trajectories. The curved catheter trajectories employed cannot be created and optimized using any other standard manufacturing process available today.

In this example case, this design effectively treat a wide irregular vaginal apex, while simultaneously achieving relatively narrow dose distribution in the anterior/posterior directions, directly translating to relative rectal and bladder sparing.

Clinically, early vaginal edema may occur after the first fraction, therefore an allowance for tissue expansion was recognized in adapting the 3-D model to the physical applicator.

Rapid-prototyping offers a feasible alternative to inflatable intracavitary applicators or interstitial brachytherapy techniques. The design of applicators is no longer constrained by standard 2D manufacturing process, and can eliminate the need for mould room resources.

**Conclusions**

**Stereolithography with high-resolution rapid prototyping:**

- Is clinically feasible for patient-specific brachytherapy.
- Allows for significant improvement in dosimetric outcomes of vaginal tissue coverage compared to standard applicators.

**References**


**Acknowledgements**

A commercialization plan for this technology is currently under development with the Sunnybrook Research Institute's Office of Technology Transfer. No conflicts of interest to declare.