

Commission a 3D Printed Applicator System for Skin Brachytherapy Treatment

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Purpose

To evaluate and determine a 3D-applicator system for skin brachytherapy treatment.

Materials and Methods

- Rectangular and curved applicators measuring 8 x 8 x 1cm with embedded tunnels fabricated using Adaptiv software and printed on MakerBot Replicator-Z18 printer.
- A series of measurements were performed to check:
 - ✓ tunnel radius
 - ✓ radius curvature
 - ✓ infill density
 - ✓ Physical integrity i.e., dimension, thickness, uniformity, and air gap.
- Tunnel radius: three sets of applicators were printed with 1.5, 2.3, and 2.5mm radius. Each tested for obstruction using 6Fr catheter.
- Radius curvature: all nine applicators were printed with 16mm-radius curvature and tested for source obstruction.
- Infill density: six applicators were printed with 50, 75, 80, 85, 90, and 95%-infill density. We then delivered radiation doses to the applicators. Measurements were compared to a water density equivalent applicator with 95%-infill density.
- An end-to-end test was performed by designing applicator for head phantom, and treatment was delivered utilizing Flexitron Afterloader.

Results/Discussions

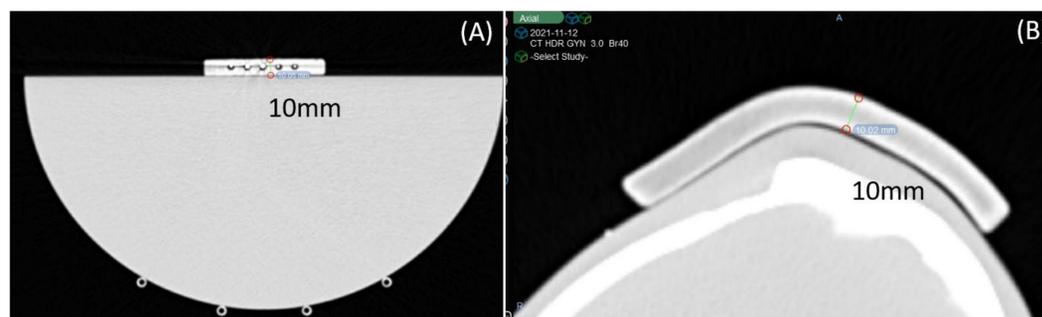


Figure 1. Thickness dimension check for rectangular (A) and for curved applicators (B).

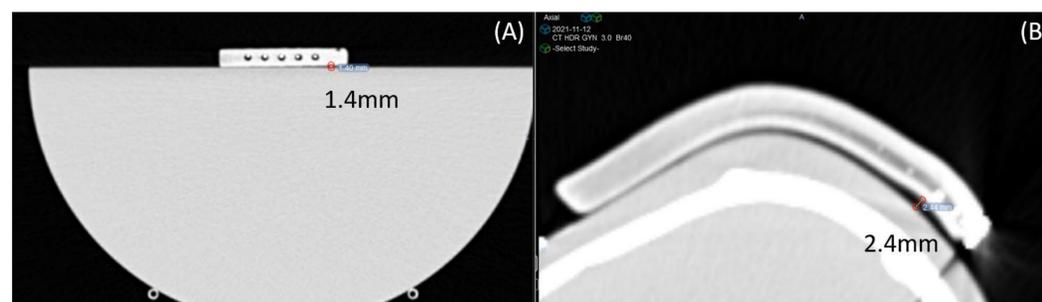


Figure 2. Air gap check for rectangular (A) and for curved applicators (B).

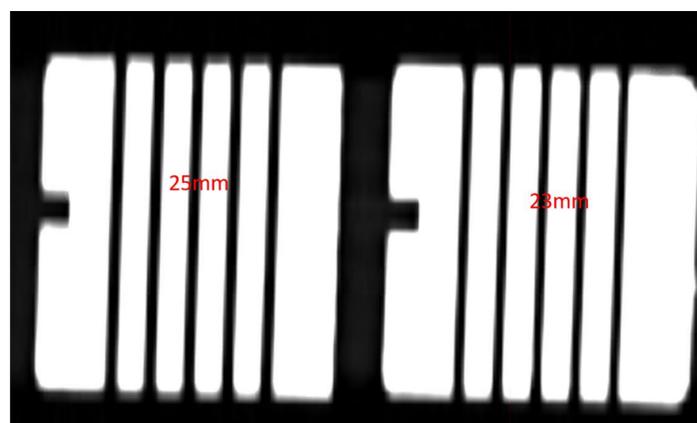


Figure 3. Applicators with 25mm and 23mm tunnel radius

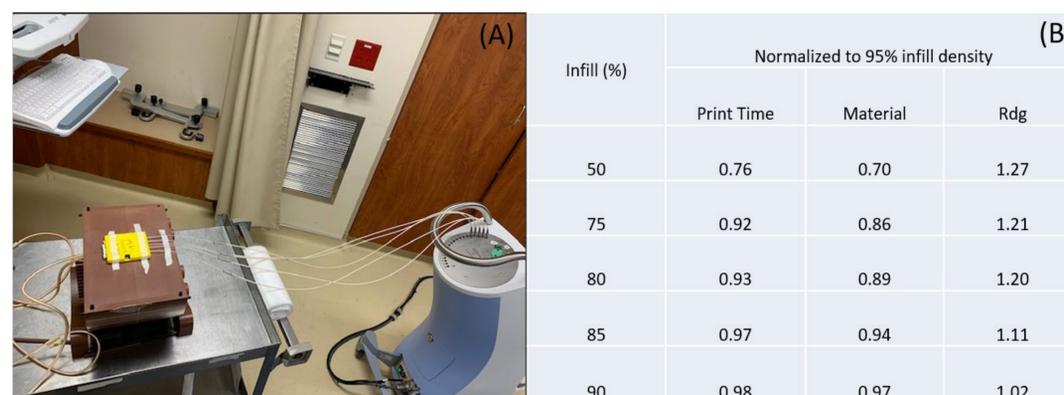


Figure 4. Infill density test setup (A) and table (B) showing values normalized to 95%-infill density applicator readings

As shown in Figure 1, all printed applicators' dimension and thickness were within 1.0 mm.

As shown in Figure 2, air gap for flat and curved applicators were within 1.4 and 2.4mm.

As shown in Figure 3, tunnel radius of 2.3mm fit the 6Fr catheter well, while 1.5mm did not allow passage and 2.5mm was too loose.

No source obstruction was detected inside all printed applicators with 16mm-radius curvature.

Infill density setting is directly related to printing time and material needed to print. As shown in Figure 4, minimal advantage is gained in reducing infill density to provide the same dose as 95% infill density. In previous work, 95% infill density resulted in water density equivalency.

An end-to-end test was performed successfully with a setting of 2.3mm radius, 16mm-radius curvature, and 95%-infill density.

Routine QA forms are created for 3D Brachytherapy treatment based on the commissioning experience.

Conclusions

This study provides a methodology to evaluate and determine settings for commercially available software and printer used in the fabrication of a 3D-applicator for skin Brachytherapy.

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