ADAPTIIV

Patient Case Study:
HDR Surface Brachytherapy for Penile Cancer

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Overview

Adaptiiv Medical Technologies Inc. (Adaptiiv) provides cancer centers with regulatory cleared software to design patient-specific radiotherapy accessories that can be 3D printed.

This case is an example of how Adaptiiv's software can be used to create customized HDR brachytherapy applicators, particularly for challenging sites with extreme curvature. A customized 3D printed applicator can be used as a solution to overcome poor setup reproducibility and inconsistent contact between skin and applicator.

Sutter Health

Patient History

A 63-year-old male with a history of psoriasis requiring chronic immunosuppression developed cutaneous squamous cell carcinoma on the left side of the glans. Patient declined surgical intervention and was referred to radiation oncology for consideration of definitive organ-sparing treatment. HDR brachytherapy was selected as the optimal treatment modality due to location and extent of disease.

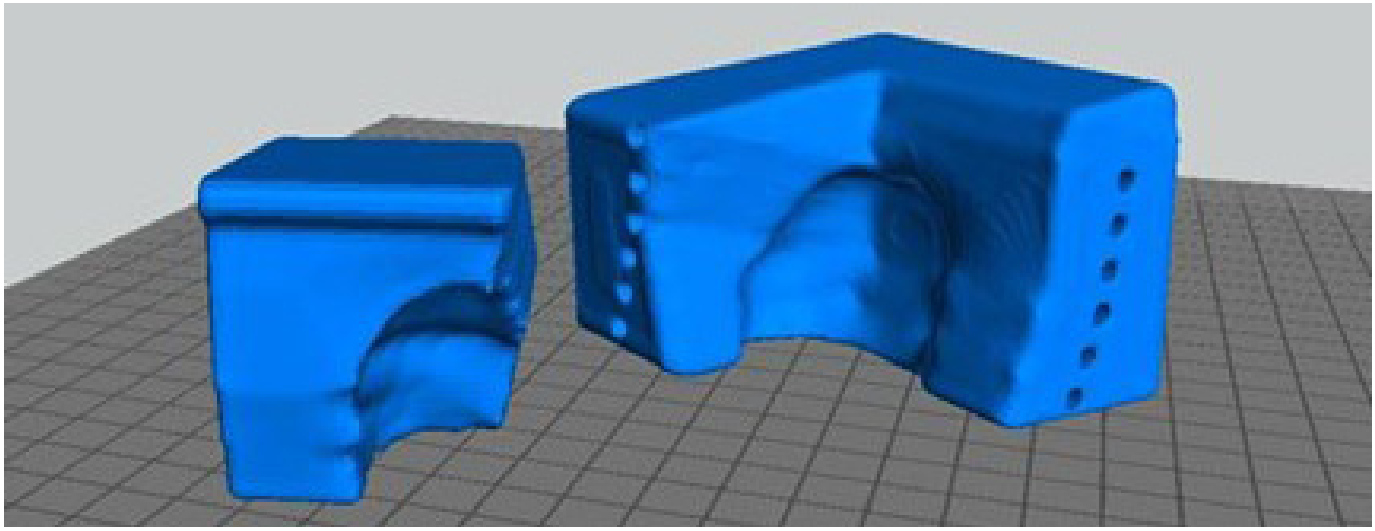
Description

Squamous cell carcinoma in situ (SCCIS) of the glans penis.

Fabrication and Treatment

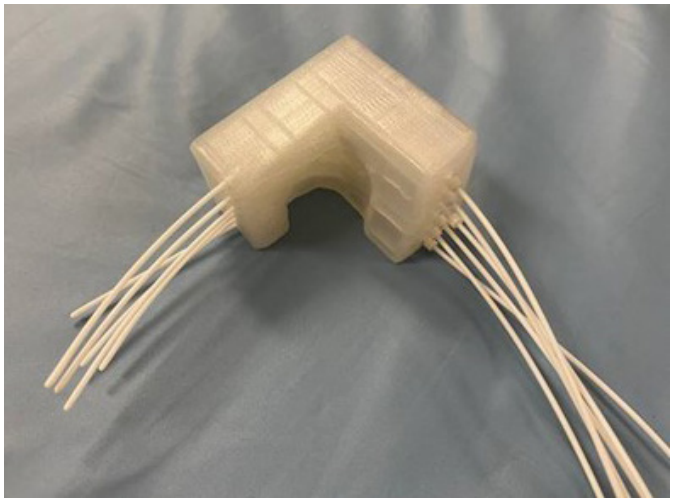
The patient was placed in a frog-legged position with an immobilization bag under the legs for setup reproducibility. An opening was drilled through a thin metal plate's center to use as a treatment platform. The opening was lined with moleskin for added comfort. The penis was positioned through the plate hole for stability. A CT scan was then acquired for applicator construction.

The initial applicator design was created in MIM Software (MIM Software Inc., Cleveland, OH) using a block contour on top of the metal plate and surrounding the penis. The block contour was then divided into 2 pieces (3/4 of the block designed with the catheter trajectories and the remaining 1/3 block for penile immobilization during treatment). The DICOM CT data and RT structure set were sent to Adaptiiv's 3D Bolus software for final applicator creation. Catheter trajectories were set 4 mm from the skin surface with 7 mm separation (6 trajectories total) inside the 3/4 block structure.



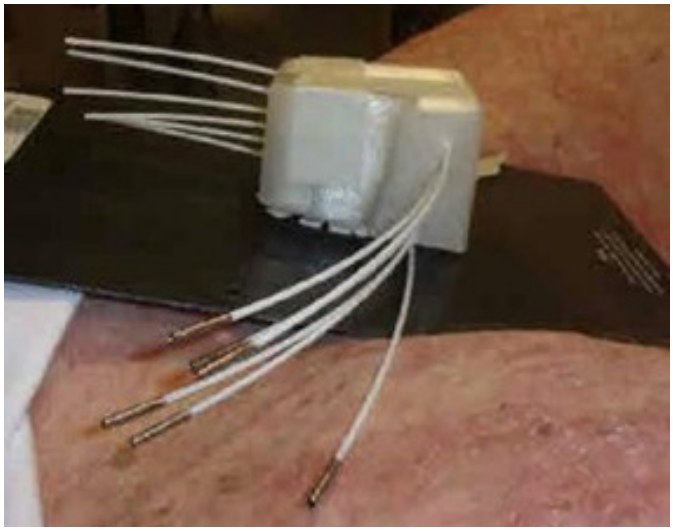
3D model of 2-piece applicator used for HDR penile cancer treatment.

The applicator was printed with an Airwolf Axiom 20 3D printer (Airwolf 3D, Las Vegas, NV) using 3D-Fuel 2.85 mm PLA filament (3D-Fuel Inc., Fargo, ND). An infill of 10% was chosen to keep the applicator light for treatment. After the print was complete, the 1.8 mm diameter 320 mm length Varian flexible mould probes (Varian Medical Systems, Inc., Palo Alto, CA) were inserted into each channel, and leak stops were used on the proximal ends to ensure catheter position reproducibility.



Customized HDR applicator printed using PLA filament at 10% infill for lighter weight. The mould probes were secured with leak stops on the proximal end and the lengths were measured before each fraction to verify daily catheter location.

The patient returned for another CT simulation with the applicator in place to verify fit. This CT dataset was used for final planning and dosimetry.



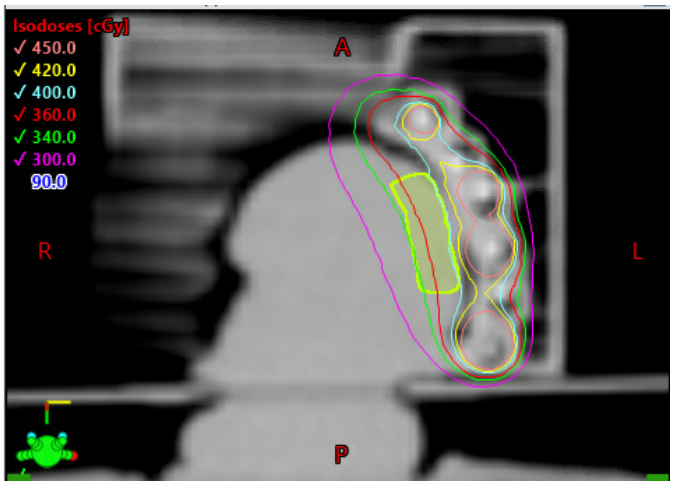
The patient was placed supine in a frog-legged position with an immobilization cushion under the legs. A metal plate with a hole was used to properly position the penis for daily treatment. The physician placed the custom applicator block with mould probes for treatment. The second block piece was then positioned and secured the applicator in place with tape.

Dose

The dosimetry was based on the 2019 publication from D'Alimonte et al., *Optimized penile surface mold brachytherapy using latest stereolithography techniques: A single-institution experience* [1]. The goal was to deliver 36 Gy at a depth of 5 mm while limiting the surface dose to 42 Gy. The treatment was delivered over 10 fractions, BID for 5 consecutive days with a minimum 6 hour gap between fractions.

Since the surface dose was the limiting constraint, the final treatment plan CTV coverage achieved D90% = 35.0 Gy and D98% = 34.2 Gy.

[1] D'Alimonte, Ravi, Helou, et al (2019). Optimized penile surface mold brachytherapy using latest stereolithography techniques: A single-institution experience. *Brachytherapy*, Volume 18, Issue 3, P348-352, 2019.



Results/Findings

Designing the applicator into 2 pieces made placement of the device easy for the physicians for each fraction. In addition, the design allowed flexibility to adjust to minor swelling of the penis over the course of treatment by placing the primary section on first, then gently securing the treatment area with the remaining piece.

Summary

1. Reproducible positioning with excellent contact between the treatment area and applicator.
2. Customized catheter trajectories for challenging geometry with extreme curvatures.
3. Optimized dose to target while minimizing surface dose.

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