Patient Case Study: Design and Fabrication of Custom, 3D Printed HDR Surface Brachytherapy Applicators[1]

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Overview

Adaptiiv Medical Technologies Inc. (Adaptiiv) provides cancer centers with the hardware, software, and materials to design and 3D print custom radiotherapy accessories.

The following case demonstrates the application of Adaptiiv's technology used in clinical radiation oncology through the design and fabrication of a patient-specific HDR surface brachytherapy applicator for the treatment of a patient with bilateral shin skin cancer. This case is a great example of how Adaptiiv's software can be effectively used to quickly create HDR surface brachytherapy applicators that provide excellent fit to patient contours and allow for simple daily set up.

Patient History

An 80 year old patient presented with bilateral basal cell carcinoma on their shins – three lesions on the right shin, two on the left shin.

[1] Chytyk-Praznik, K., Oliver, P., Allan, J., Best, L., & Robar, J. (2020). Design of Custom, 3D-Printed Surface Brachytherapy Applicators. 2020 Joint AAPM | COMP Virtual Meeting.

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Description

Superficial photon or electron beams are typically used when treating skin cancer with radiation therapy. Treatment with these modalities is most consistent when the patient contour is normal to the treatment beam. If the treatment area is large or there is more than one lesion, multiple fields may be required to obtain adequate target coverage. Planning and treating many targets on a patient's sloping contour can be particularly problematic. Additionally, the treatment of patients over several fractions creates another layer of complexity. Considering these challenges, the objective of this case was to design and fabricate patient-specific, surface HDR brachytherapy applicators that require simple daily set up for the treatment of multiple complex targets.

Fabrication and Treatment

The patient's initial CT simulation was used for applicator design, with the targets wired by the physician, as shown in Figures 1 (a) and (b). The CT dataset was imported into the Eclipse TPS (Varian Medical Systems). Individual applicators for each shin were created as "bolus" structures, using the patient's external body contour. Care was taken to control the applicator dimensions so that it would: fit on the 3D printer plate, would be shorter than the brachytherapy catheters, and would not need to be cleaved and then reattached to be placed onto the patient.

Figure 1 (a)

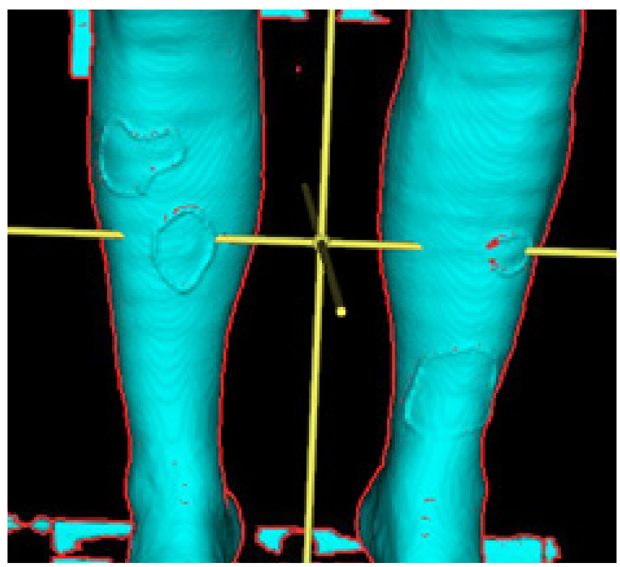

Figure 1 (b)

The Eclipse structures were imported into the HDR surface brachytherapy module of Adaptiiv software to take advantage of its automatic tunneling feature to design the catheter trajectories (see Figure 1 (c)).

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Fabrication and Treatment (continued)

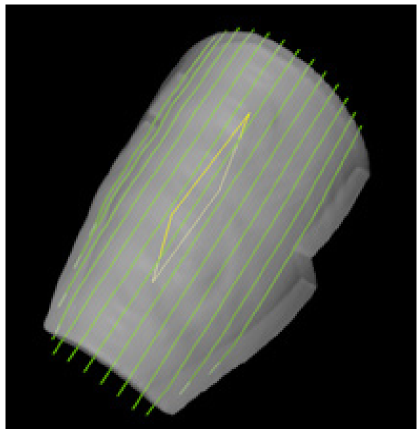

Figure 1 (c)

The applicator designs were exported from Adaptiiv software and printed with a Lulzbot TAZ 5 3D printer. Flexible 6F catheters were inserted through the tunnels and fastened in place with buttons to allow the HDR source to travel reliably through the applicator. A second CT simulation of the patient with the completed applicators and radiopaque markers inserted was required to:

- Ensure proper fit
- Verify print quality
- Create reference marks for daily setup on the patient
- Enable catheter reconstruction for treatment planning

The patient was planned in Oncentra Brachy (Elekta), with two treatment plans – one for each shin.

Figure 2 (a)

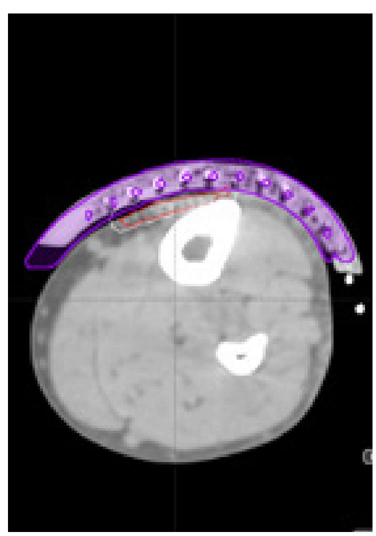

Figure 2 (b)

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Dose

The targets were prescribed 40 Gy in 15 fractions with HDR surface brachytherapy.

Results and Findings

Each applicator required 13 catheter tunnels to encompass the CTVs in all directions, with at least one catheter tunnel lateral to the wired targets. After minor adjustments during the second CT simulations, the applicator fit the patient's body contour and matched the modelled applicator well, as shown in Figures 2 (a) and (b). The first CT dataset was co-registered to the second dataset to allow contouring (from the wired mark-ups on the first CT scan) and planning (with the radiopaque markers and completed applicators on the second CT scan) to occur on the second set of simulation images.

The CTVs were designed to treat to a 3 mm depth, with a 3 mm PTV margin in the lateral and superior-inferior directions to account for daily setup variations. The resulting plan was able to cover greater than 98% of the PTV with 100% of the prescription, and mostly contained the 150% isodose to the applicator, minimizing the volume of target that receives the high dose (see Figure 3).

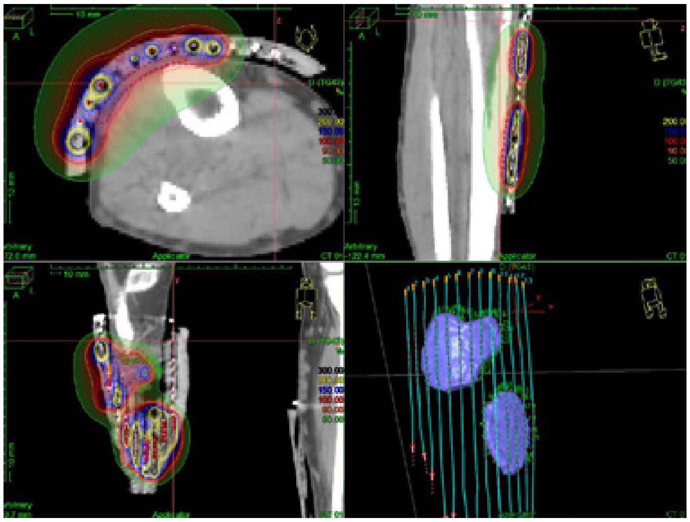

Figure 3

Summary

1. 3D printed HDR surface brachytherapy applicators designed in Adaptiiv software can be successfully used to treat patients with bilateral shin skin cancers.
2. The 3D printed applicator provided excellent fit to the patient's contour, with simple daily setup and ease of use for treatment.

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