Patient Case Study:

External Beam Electron Treatment of Nasal Squamous Cell Carcinoma with 3D Printed Modulated Bolus

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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 report provides an excellent example of how Adaptiiv's software can be effectively used to generate a customized modulated electron bolus (MEB) for an irregular surface region with consistent patient setup reproducibility, improved dose conformity and accurate dose delivery.

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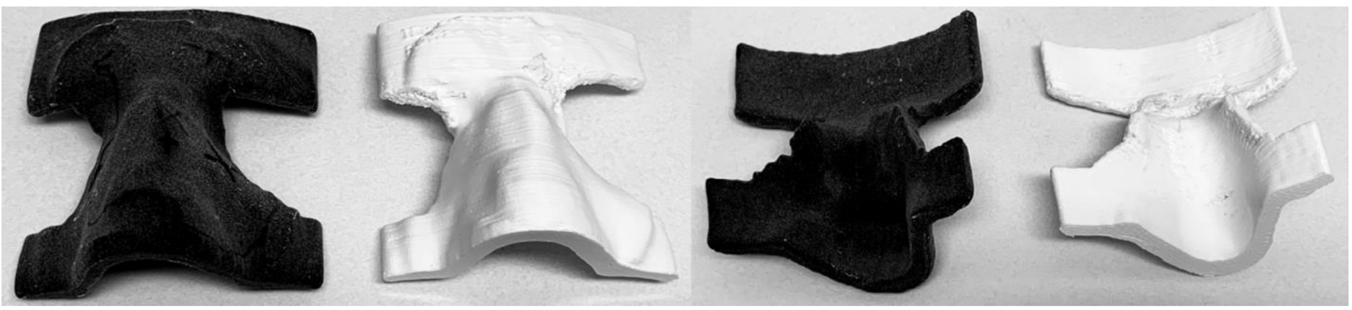
Description

Squamous cell carcinoma of the left nasal bridge.

Patient History

A 67-year-old male with a history of extensive sun exposure and multiple prior resected skin cancers presented with a well differentiated squamous cell carcinoma of the left nasal bridge. He was initially assessed by a dermatologist who recommended surgical resection. He therefore underwent a Mohs resection, with negative radial margins, and a positive deep margin that could not be cleared surgically. As a result, adjuvant radiation therapy was recommended to reduce chance of local recurrence.

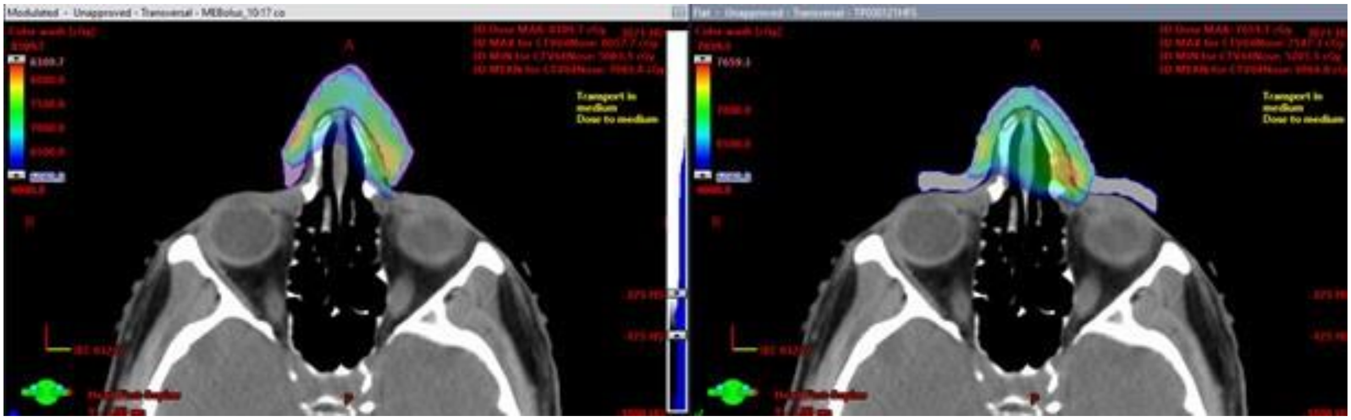
Fabrication and Treatment



The modulated bolus plan is on the left and the uniform thickness bolus plan is on the right. Improved conformity and reduced dose spill can be observed. Dose in the bolus is non-consequential.

A MEB was fabricated to treat the nasal bridge post-operative bed. The bolus was modulated in order for the prescription dose to conform to the target and reduce extra high dose spillage to the surrounding normal tissue. Aside from dose conformity, the custom 3D bolus was chosen over a flat sheet bolus to minimize the possible air gap that could occur between the bolus and the patient surface. Although wet gauze/towel bolus may be a reasonable option to limit the air gap, the humidity level can differ on a daily basis decreasing reproducibility. 3D printed bolus can provide a consistent density, thus more accurate dose delivery can be achieved.

This image shows the TPU01 bolus with custom lead blocks wrapped in wax. The purpose of the wax was to reduce electron side scatter.



This image shows modulated bolus plan on the left and the uniform thickness bolus plan on the right. Improved conformity was achieved with modulated bolus.

The final modulated electron bolus was shaved off around the orbit in the treatment planning system (TPS) for lead block placement in order to protect the tear duct, eyes and lenses. The modified bolus structure was sent to Adaptiiv software to prepare the stereo lithographic (STL) file for the 3D printing.

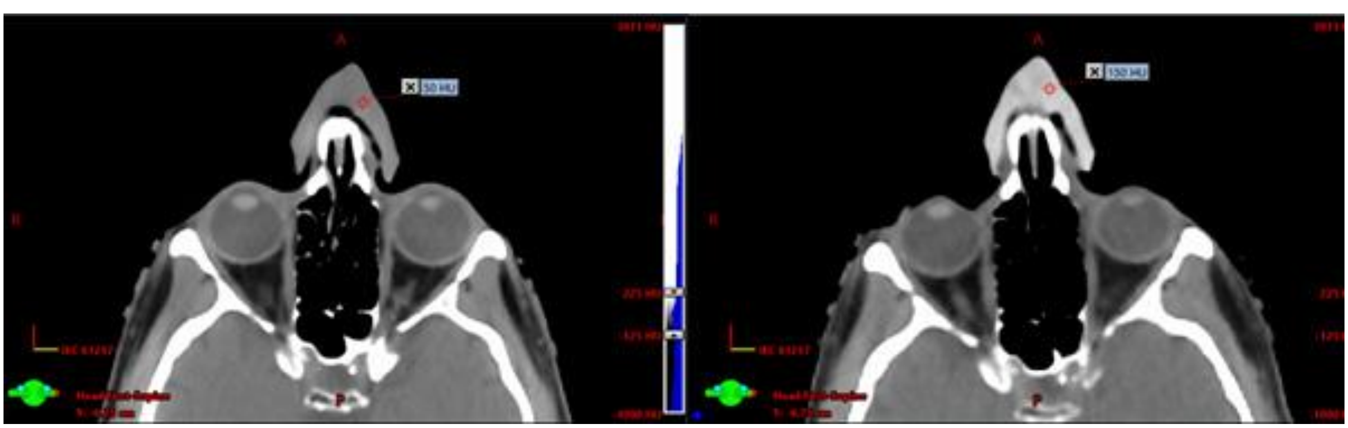
The bolus was printed in-house using an AXIOM 20 3D printer with standard Polylactic acid (PLA) filament. Another copy was printed by Adaptiiv's on-demand service using a TPU filament.

Dose

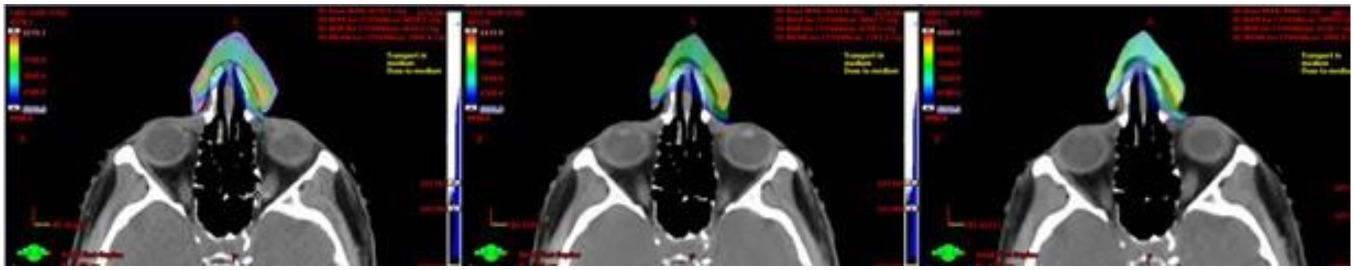
The prescription dose was 6400 cGy in 32 fractions using 9 MeV electrons. The orbits were blocked using a custom Cerrobend cutout. Lead blocks were prepared to be placed on patient's surface for extra shielding.

Results/Findings

A verification computerized tomography (CT) scan of the patient was performed with the PLA and TPU01 boluses. Some air gaps were noted in the verification CT scans. This is due to the body contour design around the wires placed to mark the lesion in the planning CT scan.



This image shows the air gap and bolus density of the TPU bolus (on the left) and PLA bolus (on the right).



This image shows the air gap and HU of the TPU01 bolus (on the left) and PLA bolus (on the right).

Moving forward, our 3D bolus patients will be scanned twice, with and without wires, for target delineation and planning. Both CT scans showed good Hounsfield units (HU) uniformity inside the two boluses with the average HU of 150 for the PLA and 50 for the TPU01 bolus.

The original plan was copied onto the verification CT scans after the images were co-registered. Dose was then computed with the original plan parameters, but accounting for the air gap and bolus density.

Target coverage on the two verification plans, with the PLA and TPU01 boluses, was similar to the original modulated electron bolus plan. However, the global maximum dose had increased by approximately 2%. The hot spot was within the bolus material, making the plan clinically acceptable. The TPU01 bolus verification plan was used as the final plan for treatment delivery.

Summary

1. Customized bolus for lead shield placement
2. Improved target conformity through electron modulation
3. Reduced possible air gaps by using a patient customized 3D bolus
4. Provided consistent bolus density for accurate dose delivery

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