Patient Case Study:
Comparing 3D Printed Bolus to a Standard Vinyl Gel Sheet Bolus for Post-Mastectomy Chest Wall Radiation Therapy

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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 patient case study evaluates the usage of a 3D printed bolus compared to a standard sheet bolus for chest wall radiation therapy based on the accuracy of fit, surface dose measured in vivo, and the efficiency of patient setup. The results demonstrate that the 3D printed bolus in post-mastectomy radiation therapy provides a better bolus fit and reduces patient setup time compared with sheet bolus. More details can be found in the published article listed below.[1]

[1]Robar, et al (2017). Intrapatient study comparing 3D printed bolus versus standard vinyl gel sheet bolus for postmastectomy chest wall radiation therapy. Practical Radiation Oncology, 8(4), 221–229. https://doi.org/10.1016/j.prro.2017.12.008

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Patient Selection

16 eligible breast cancer patients receiving post-mastectomy chest wall radiation therapy were selected for the study. Criteria included (1) anticipated use of tangential fields in treatment planning and (2) requirement for bolus on alternate treatment fractions. Of the 16 eligible patients, 12 were treated for right- and 4 for left-sided disease. The median age of the 16 patients with breast cancer was 61 years with a range of 38-83, and the median body mass index was 26.1 kg/m² with a range of 18.7-34.9. Each patient served as their control by alternating bolus type throughout therapy.

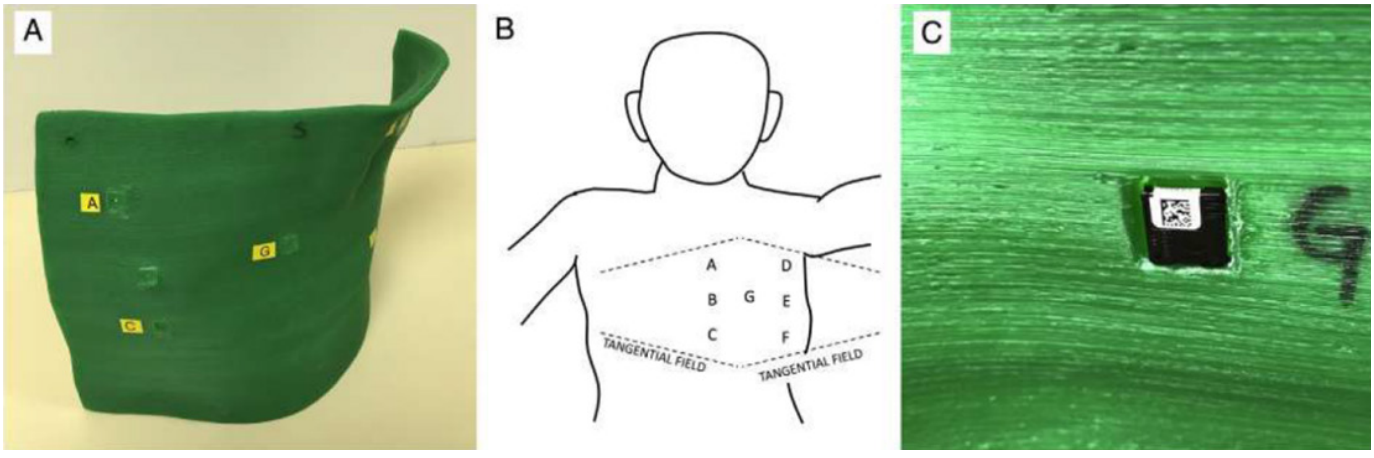
Description

There is growing interest in 3D printing in the radiation therapy process, and a natural application of this developing technology is the generation of treatment accessories based on CT image data. This work presents the findings of a study of 16 patients in which a 3D printed chest wall bolus was compared directly to the status quo sheet bolus (SuperFlab) in the same individual's treatment, with three objectives of evaluation:

1. To determine whether a 3D printed bolus provides a more accurate fit to the patient surface based on cone-beam CT imaging.
2. To compare the 2 bolus types concerning in vivo dosimetry of dose to the skin's surface.
3. To provide comparative data regarding the efficiency of patient setup at the treatment unit.

Fabrication and Treatment

The treatment planning system defined a bolus of 5.0 mm thickness and exported it as a polygon file format object. This structure was manipulated in Adaptiiv software to apply smoothing and to crop at the inferior edge for subsequent optimal adhesion to the 3D printer build plate; an example bolus is shown in Figure 1 (A). All boluses were 3D printed using fused deposition modeling of polylactic acid (PLA) filament. This material offers the advantages of being non-toxic, easily cleaned during the treatment course, and compared with some other materials, faster during 3D printing.



(A) Example of a 3-dimensional printed bolus.
(B) locations of 7 OSLDs (labeled A to G) relative to patient and tangential fields.
(C) embedded OSLD contained by in-printed pocket, where OSLD is flush with the skin side of the bolus surface.

Results/Findings

This case study demonstrates the practical use of 3D printed bolus for post-mastectomy radiation therapy. In the sample of 16 patients, each treated at least 4 times with 3D bolus, the accuracy of fit of the 3D bolus to the chest wall was improved relative to standard sheet (SuperFlab) bolus, with the frequency of air gaps ≥5 mm reduced from 30% to 13%. The surface dose was measured using in vivo dosimetry and was within 3% for sheet and 3D printed bolus. There was no significant difference between sheet and 3D printed bolus concerning agreement with the treatment planning system. The setup time was reduced only marginally with a 3D printed bolus (104 to 76 seconds). However, this time saving must be weighed against the considerable time required to fabricate the bolus (median, 10.8 hours; mean, 12.6 ± 5.4 hours) and related quality assurance, although the printing process was largely automated.

Summary

1. 3D printed bolus in post-mastectomy radiation therapy improves the fit of the bolus and reduces patient setup time (from 104 to 76 seconds, on average, in this study).

2. The accuracy of fit of the bolus to the chest wall was improved significantly relative to standard sheet bolus, with the frequency of air gaps 5 mm or larger reduced from 30% to 13% ($P < .001$) and maximum air gap dimension diminished from 0.5 ± 0.3mm to 0.3 ± 0.3mm on average.

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