Case Study Comparing 3D Printed Bolus Versus Standard Vinyl Gel Sheet Bolus for Postmastectomy Chest Wall Radiation Therapy

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Overview

This patient study evaluated the use of 3-dimensional (3D) printed bolus for chest wall radiation therapy compared with standard sheet bolus with regard to accuracy of fit, surface dose measured in vivo, and efficiency of patient setup. It demonstrates 3D printed bolus in postmastectomy radiation therapy improves fit of the bolus and reduces patient setup time compared with standard vinyl gel sheet bolus. More details can be found in the published article listed below. More details can be found in the published article listed below.[1]

Patient Selection

16 eligible breast cancer patients receiving postmastectomy chest wall radiation therapy were selected for the study, where 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 and 4 were treated for right- and left-sided disease, respectively. The median age of the 16 patients with breast cancer was 61 years (range, 38-83), and the median body mass index was 26.1 kg/m2 (range, 18.7-34.9). By alternating bolus type over the course of therapy, each patient served as her own control.

Description

There is growing interest in the application of 3-dimensional (3D) printing to the radiation therapy process, and a natural application of this developing technology is the generation of treatment accessories based on computed tomography (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 individuals, with 3 main goals: (1) to determine whether a 3D printed bolus provides a more accurate fit to the patient surface based on cone beam CT (CBCT) imaging, (2) to compare the 2 bolus types with regard to in vivo dosimetry of dose to surface of skin, and (3) to provide comparative data regarding the efficiency of patient setup at the treatment unit.

[1] *Robar, et al (2018). 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

Fabrication and Treatment

Bolus of 5.0 mm thickness was defined in the treatment planning system and exported as a polygon file format object. This structure was then manipulated in 3D design software to apply smoothing and to crop at the inferior edge for subsequent 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 nontoxic, easily cleaned during the treatment course, and, compared with some other materials, faster during 3D printing.

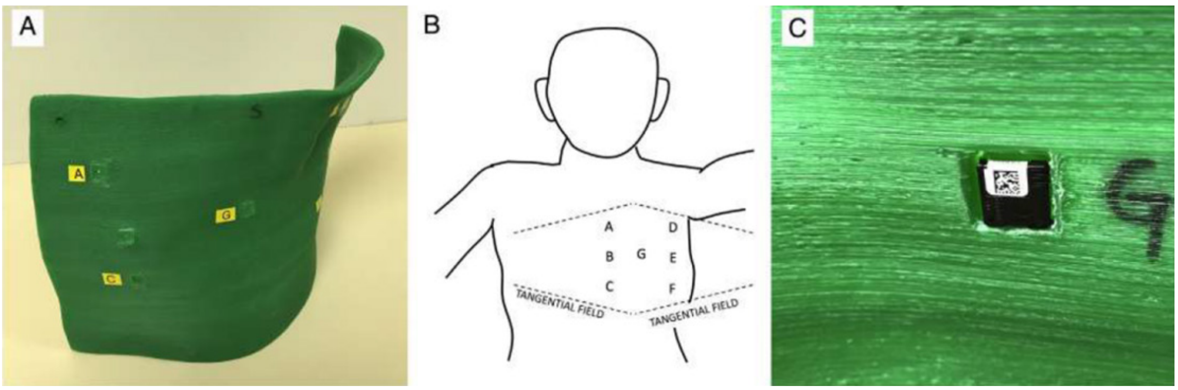

FIgure 1.
(A) Example of a 3-dimensional printed bolus.
(B) locations of 7 OSLDs (labeled A to G) relative to patient and tangential fields.
(C) embedded OSLD contained by in-printed pocket, where OSLD is flush with the skin side of the bolus surface.

Results / Findings

This study demonstrates the practical use of 3D printed bolus for postmastectomy radiation therapy. In a 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%. Surface dose, as measured using in vivo dosimetry, was within 3% for sheet and 3D printed bolus, and there was no significant difference between sheet and 3D printed bolus with regard to agreement with the treatment planning system. The setup time was reduced only marginally with 3D printed bolus (from 104 to 76 seconds); however, this time saving must be weighed against the considerable time required for fabrication of the bolus (median, 10.8 hours; mean, 12.6 ± 5.4 hours) and related quality assurance, although the printing process was found to be largely automated.

Summary

1. 3D printed bolus in postmastectomy radiation therapy improves 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 greater reduced from 30% to 13% ($P < .001$) and maximum air gap dimension diminished from 0.5 ± 0.3 to 0.3 ± 0.3 mm on average.