Evaluation of a silicone-based custom bolus for radiation therapy

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INTRODUCTION

Standard-of-care boluses for radiation therapy may not adequately conform to patients' unique topographies, resulting in air gap between the target surface and bolus. This is particularly problematic with superficial pelvic tumors.

As a result of air gap, the radiation dose received by the target site may be inconsistent with the prescribed dose.

AIM

To increase predictability and homogeneity of radiation dose in cases with air gap, we created a custom bolus and evaluated it against the clinical standard.

METHODS

- Collect CT simulation scans of anthropomorphic phantom and on-treatment patient, focusing on pelvic region
- Design molds from CT scans, 3D print molds, and cast molds with silicone rubber to create custom boluses
- Collect air gap measurements on standard-of-care and custom boluses by analyzing total volume between the bolus and target surface, as measured from another set of CT scans.
- Deliver therapeutic radiation doses to phantom using standard-of-care and custom boluses. Measure dose at 9 points on the phantom and compare to expected dose calculated by treatment planning software.

RESULTS

Custom molds and silicone boluses were successfully created for both the anthropomorphic phantom (Figure 1) and on-treatment patient.

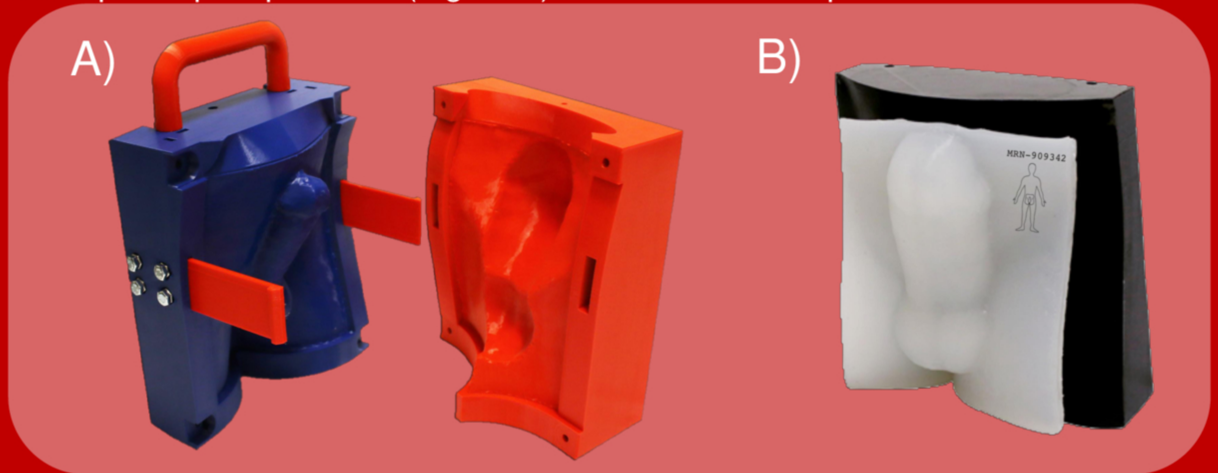


Figure 1. A) 3D-printed mold created from the phantom's CT-simulation scan. B) Custom silicone rubber bolus on the phantom. The custom bolus was created by casting the 3D-printed mold.

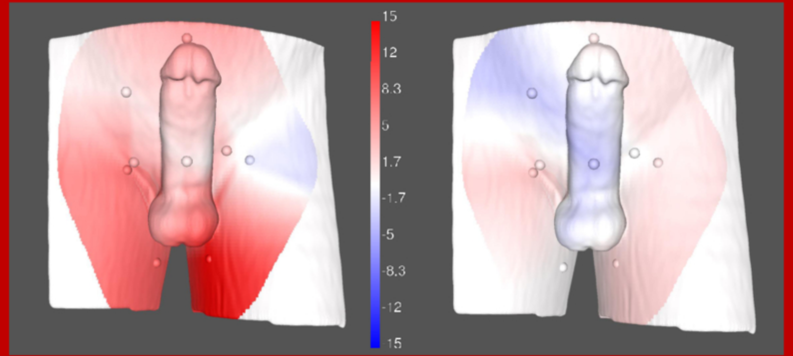
- Mean air gap volume between the bolus and phantom was reduced by 98.5% using the custom device instead of the standard. In the patient trial, the air gap volume was reduced by 72.7% using the custom device. Total air gap volume measurements are reported in Figure 2.
- Phantom dosimetry test showed that the mean and maximum difference between expected and received doses was smaller with the custom bolus than the standard. Differences between predicted and received radiation dose are reported in Figure 3.
- Areas of larger dose difference corresponded to areas with larger air gap.
- Setup time was reduced from 4-5 minutes with the standard bolus to less than 1 minute with the custom bolus. Reducing time taken to arrange the bolus could increase clinic productivity.

Air gap comparison on CT scans

	Standard bolus	Custom bolus
Patient	169 cm^3	46.1 cm^3
Phantom	314 ± 141 cm^3	4.56 ± 1.59 cm^3

Figure 2. CT scan images of the standard bolus on the phantom (left) and the custom bolus on the phantom (right). Total air gap volumes are reported as mean±SD.

Difference between predicted and received radiation dose



	Standard bolus	Custom bolus
Difference	5.69 ± 4.56%	1.91 ± 1.31%
Maximum difference	15.1%	3.51%

Figure 3. Visualization of dose difference with standard bolus (left) or custom bolus (right) relative to an idealized bolus with no air gaps (calculated by the treatment planning system). Differences are reported as mean±SD. Measurement locations are denoted with dots. Dose difference values were interpolated between measured locations.

CONCLUSIONS

The custom bolus reduced total airgap volume and increased predictability of radiation dose delivered as compared to the standard bolus. The custom bolus could increase the certainty of prescribed dose delivery of radiation therapy for superficial tumors.

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