3D Rapid Manufacturing Bolus vs Commercial Bolus – Skin Dose Comparison

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Introduction

Most of the breast radiotherapy treatments use megavoltage photon beams. This kind of energy exhibits a skin-sparing effect that is a concern in some stages of both breast conservative and post-mastectomy irradiation. To overcome this effect a bolus material is placed on the skin. However, when using commercial non-customized bolus, small air gaps can occur in certain regions of the treatment area where the bolus cannot establish the perfect match with the irregular skin of the patient, changing locally the expected skin dose.

The objective of this study is to verify the improvement in the breast radiotherapy treatment using a customized bolus produced by 3D rapid manufacturing (3D-RM) techniques, and compare it with the commercial ones (Superflab).

Measurement of the surface dose and comparisons with the doses calculated by the Treatment Planning System (TPS) were also performed.

Materials & Methods

The customized 3D rapid manufactured bolus (3D bolus) was prepared by 3D-RM technique for an anthropomorphic female phantom breast area. 3D-CRT treatment plans for right breast were performed on CT scans of the phantom both with the customized and commercial bolus. The plans were compared to the standard plan, calculated with a virtual bolus assigned by the TPS. For dose measurements the skin dose was measured in 5 points on the phantom breast surface using a MOSFET-based system.

References

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Results & Discussion

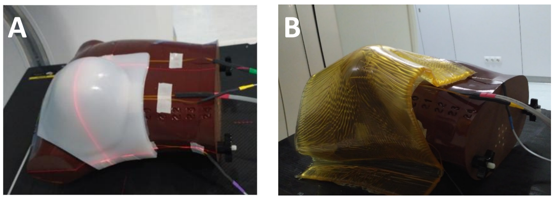

Fig. 1 – 3D bolus (A) and the Superflab bolus (B) placed on the anthropomorphic female phantom.

The surface adjustability was assessed by both visual inspection and evaluation of CT axial and sagittal planes. The Superflab bolus confirms the difficulties often found in placing it on an irregular surface, causing air gaps, as we can observe in Fig. 1.

The 3D bolus customized shape has a perfect fit to the phantom surface.

The Fig.2 represents axial and sagittal planes, with the two boluses types. The results of the visual inspection were corroborated by the CT images acquired with the two boluses in place. Again, the difference in fit between the two boluses is evident along the surface of the phantom. The 3D bolus shows to be more efficient than the commercial one for surface fit adjustment.

I) II)

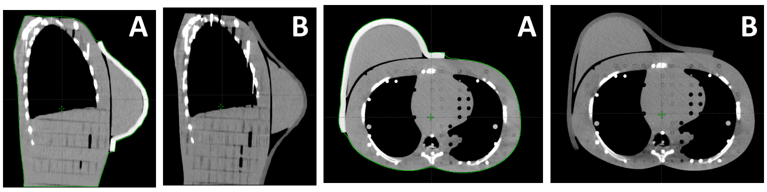

Fig. 2
I) Sagittal plane and II) Axial plane comparing the surface fit effectiveness between 3D bolus (A) and Superflab bolus (B).

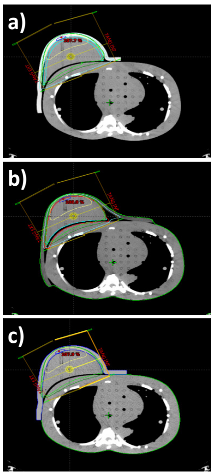

Fig. 3 – 3D-CRT plans using 3D bolus (a), Superflab bolus (b) and virtual bolus (c).

For *in vitro* measurements, 3DCRT treatment plans were performed in the RANDO phantom for a right breast, using two parallel opposed tangential fields with 6 MV photon beams.

The prescription dose for a whole breast volume was 50Gy in 25 fractions. The same planning parameters were used for all 3D-CRT plans. Dose distributions were calculated using the analytical anisotropic algorithm (AAA) with a calculation grid size of 2 mm.

The sensitivity points of the detectors were accurately placed in 5 points on the phantom surface (Fig. 4), for *in vitro* measurements.

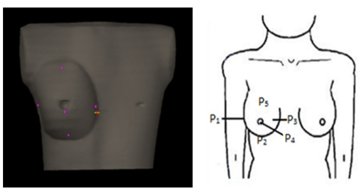

Fig. 4 – Positions selected for MOSFET dosimeters.

MOSFET	3D Bolus	Superflab bolus
	Measured (Gy)	
P1	1,90	1,87
P2	2,05	2,02
P3	1,82	1,80
P4	2,01	2,00
P5	1,91	1,88
	Calculated (Gy)	
P1	1,94	1,93
P2	2,16	2,15
P3	1,91	1,91
P4	2,17	2,16
P5	2,08	2,08

$$\%diff = \frac{Measured\ dose - Calculated\ dose}{Calculated\ dose} \times 100 \quad \text{eq.1}$$

MOSFET	3D Bolus	Superflab bolus
	(%)	
P1	1,91	3,21
P2	4,87	6,13
P3	4,71	5,76
P4	7,20	7,45
P5	8,08	9,57

The average differences, calculated according the eq.1, between calculated and measured doses in the 3D bolus and Superflab bolus, ranged from 2-10% as observed in the first table. However, the highest dose difference (approximately 10%) was observed for the Superflab bolus.

Conclusions

Customized bolus was successfully manufactured using 3D-RM techniques. The 3D rapid manufactured bolus can reduce the uncertainty in the daily positioning and help to overcome the dose discrepancy due to unwanted air gaps affecting breast cancer radiation therapy. With the commercial bolus a higher dose difference relatively to TPS was observed. The skin dose increase is observed in the same proportion for both boluses.