Fabrication of three-dimensional printed customized bolus for the irregular shape of the outer ear

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Purpose and Objective

- The skin-sparing effect of megavoltage-photon beams in radiotherapy reduces the target coverage of superficial tumours.
- Consequently, a bolus is widely used to enhance the target coverage for superficial targets. Commercial bolus cannot easily be applied on irregular surfaces. A three-dimensional (3D)-printed customized bolus (3D bolus) can be used for radiotherapy application to irregular surfaces. This study examines the possibility of the fabrication of a 3D customized bolus for an irregular surface.
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Material and methods

- We fabricated a bolus using a computed tomography (CT) scanner and evaluated its efficacy. The head of an Alderson Rando phantom was scanned with a CT scanner.
- A 3D bolus of 5-mm thickness designed to fit onto the ear was printed with the use of a Stratasys Objet260 Connex3 with the use of PolyJet technology (Stratasys Ltd., Eden Prairie, MN, USA) with the malleable `rubber-like' printing material, Agilus (Stratasys Ltd.).
- CT simulations (Figure 1) of the Rando phantom with and without the 3D and a commercial high density bolus (eXaSkin©) were performed to evaluate the dosimetric properties of the 3D bolus. The ear was delineated as the target (15 cc).
- Radiotherapy plans with two beams were generated in the Oncentra Masterplan v4.1 radiotherapy treatment planning system with the use of the enhanced collapse cone algorithm.
- The prescription dose was normalized for 95% of the prescribed dose to cover 90% of the target volume in the plan without bolus. The plans with the bolus were normalized to ensure that the target dose lie within 95% and 107% of the prescription dose. The following dosimetric parameters were estimated for all cases: maximal dose (Dmax), mean dose (Dmean), minimum dose (Dmin), V95% (volume receiving at

Results

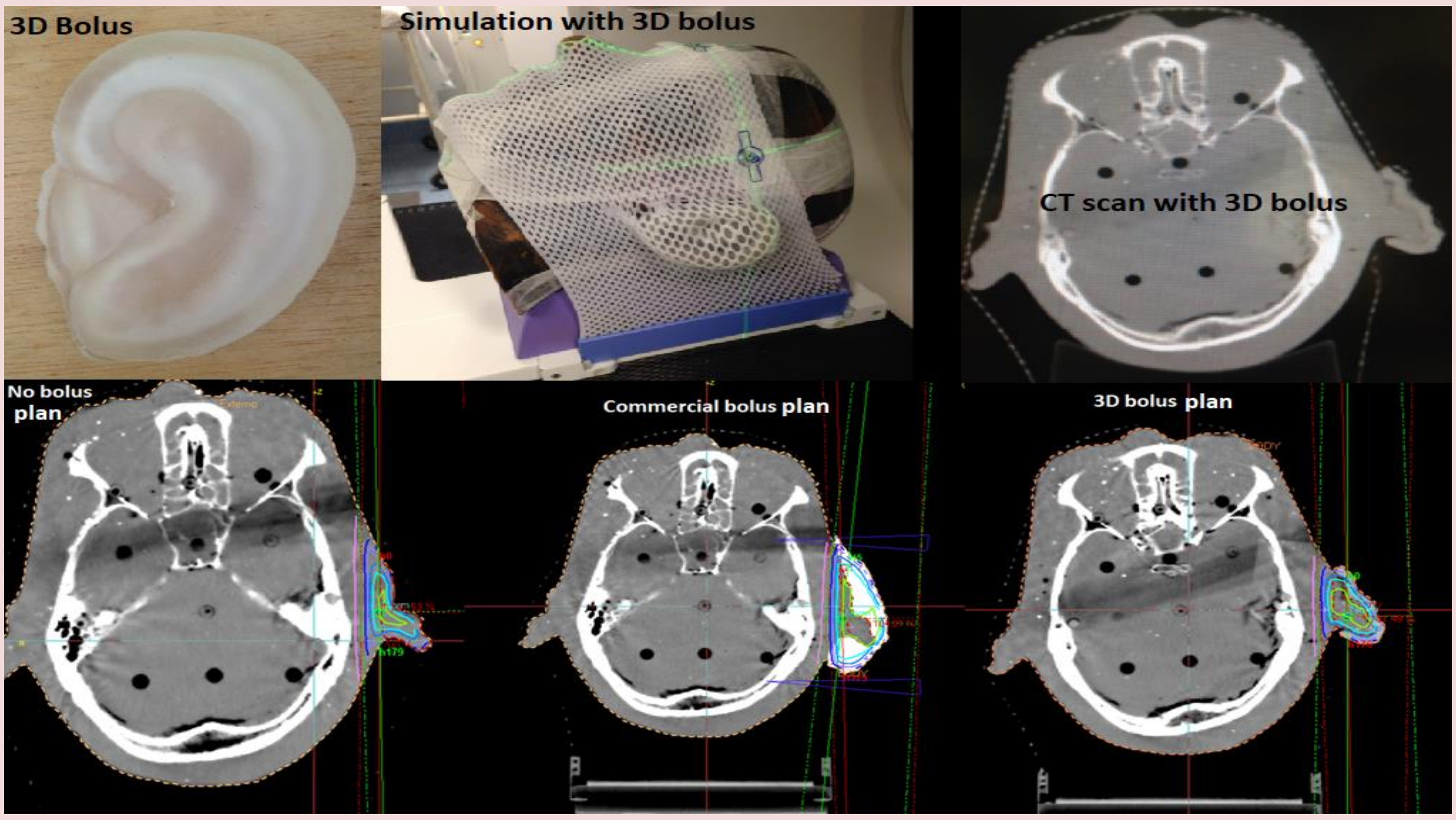
We fabricated the customized 3D bolus, and further, a CT simulation indicated an acceptable fit of the 3D bolus to the ear (Figure 1).

Due to the irregular shape of the outer ear anatomy, there was some air gap between the bolus and the phantom surface with both the commercial and the 3D bolus.

Figure 1 shows the isodose lines corresponding to the plans with and without the bolus. We observe that the target coverage is better with the bolus and it is similar between the commercial and the 3D bolus.

Table 1 summarizes the relevant dosimetric parameters for the three plans.

Parameter	No bolus	3D bolus	Commercial bolus
Dmax (%)	123.27	110.08	105.43
D98%(%)	0	94.39	97.77
Dmean (%)	109.10	105.77	101.95
Dmin (%)	0	83.64	96.08
D2%(%)	121.62	108.34	104.73
D95%(%)	77.04	97.5	98.47
V95%(%)	79.19	97.58	100
V90%(%)	79.19	97.58	100
V98%(%)	75.35	94.55	100
Homogeneity index	Non-calculable	0.13	0.07



Conclusions

- We successfully fabricated a customized 3D bolus for an irregular surface using a CT scanner.
- The fabrication process was simple and fast. The bolus, made of the malleable material Agilus, suitably fitted the surface, and the surface dose was sufficiently enhanced.
- Thus, we believe that the use of malleable materials can be seriously considered for the fabrication of customized boluses..

ESTRO37 EP-2174
Physics track: Implementation of new technology, techniques, clinical protocols or trials (including QA & audit)
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DOI: 10.3252/pso.eu.ESTRO37.2018
Poster presented at: