

Comparison of flexible silicone bolus versus 3D printed rigid bolus for the treatment of recurrent basal cell carcinoma of the inner canthus

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Introduction and Objective

Three dimensional (3D) printing technology was utilized in the fabrication of flexible silicone bolus and compared to rigid 3D printed bolus to determine whether it yielded comparable or improved plan metrics for treatment of an inner canthus tumor.

Methods and Materials

Target volumes were contoured in the Eclipse planning system (v13.6, Varian Medical). Electron plans were generated with a bolus contour that was modified to optimize dose distribution. The bolus contour was exported and the rigid bolus was printed using a Taz5 3D printer. For the silicone bolus, a 4 mm outside wall structure (mold) was applied to the bolus contour and this was exported and printed. A two part silicone rubber was mixed, then poured into the mold and allowed to cure.

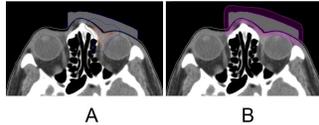


Figure 1. A) Customized bolus structure with preliminary target volumes GTV (red), CTV (orange), PTV (blue) and 4 mm wall structure (purple) B) Customized bolus structure showing 4 mm wall structure (purple)

CT images were acquired with and without an internal eye shielding (IES) for both the rigid and silicone boluses. The rigid bolus included a soft bolus plug over the eye to allow placement of the IES.

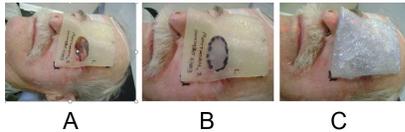


Figure 2. A) Internal eye shield and 3D rigid bolus placement B) 3D rigid bolus with soft bolus plug C) Silicone bolus

Electron plans were normalized at D_{max} using 12 MeV with a dose of 6000 cGy in 30 fractions prescribed to 100%. Evaluation metrics included: D_{max} to 0.1 cc of the PTV, organ at risk (OAR) D_{max} for the right/left lenses, optic nerves, eyes, and the left lacrimal gland.

Results

The data export and preparation times prior to 3D printing of the two boluses were identical, however with more manual intervention required for the silicone bolus. The rigid bolus required 4 hours to print. The bolus mold required 1.5 hours to print, 0.5 hours for preparation and pouring of the silicone rubber and 6 hours for curing. Both showed good conformity to the body surface. The air gap volume over the inner canthus was 1.27 cc for the 3D rigid bolus (corresponding to the location of the soft bolus plug, which was not shaped to fit the skin surface). The measured air gap volume under the silicone bolus in this same region was 0.24 cc. Both demonstrated good material homogeneity with Hounsfield units (HU) between 120-150 HU and 160-190 HU for the rigid and silicone boluses respectively.

PTV D_{max} for rigid bolus was 125.5 % versus 116.6 % for the silicone bolus. D_{max} for OARs were comparable with maximum difference of 14 % . D_{max} for the LT eye was higher for the rigid bolus.

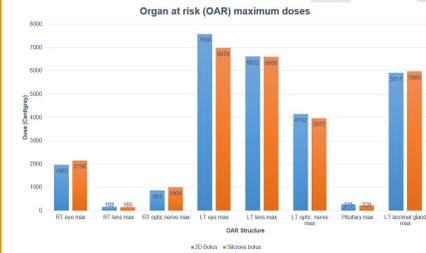


Figure 3. Maximum doses to organs at risk: 3D rigid bolus (blue) versus silicone bolus (orange)

Discussion

The silicone required a net increase of 4 hours longer to create compared to the rigid bolus. The additional time required was within the workflow guidelines of the department for the fabrication of customized bolus.

While both boluses showed close fit to the skin surface, the generic bolus plug for the rigid bolus introduced an air gap producing a higher D_{max} to the PTV distal to the air gap and a higher D_{max} to the left eye. The soft and malleable nature of the customized silicone bolus allowed it to be placed over the internal eye shield without modification. Because the silicone bolus maintained a better fit the air gap was smaller resulting in a lower D_{max} to the PTV and left eye.

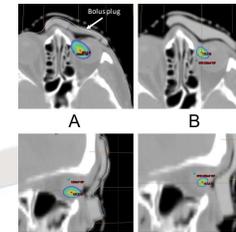


Figure 4. Axial and sagittal views showing air gap and 115 % isodose wash A) 3D rigid bolus with soft bolus plug and B) flexible silicone bolus

The flexible and malleable nature of the silicone bolus required careful placement for daily treatment to ensure the proper fit. A cone beam CT (CBCT) was taken daily to verify the bolus position.

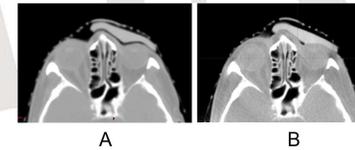


Figure 5. Axial images of silicone bolus on A) Planning CT image at simulation B) CBCT on treatment unit

Conclusion

The minimal additional workflow requirements for fabrication of silicone bolus and comparable plan metrics with 3D rigid bolus make it a potentially viable option for bolus application. Further study to assess flexible silicone bolus for clinical use is warranted.