Evaluation of a brass surface collimator for superficial irradiation using high-energy electrons: a case study

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Introduction

Purpose. Electron therapy allows for superficial dose deposition but suffers from bulging dose clouds deeper within the patient. This work presents a case where a patient was treated for a superficial skin tumor in the scalp where the target was adjacent to previous radiation treatment. To increase dose falloff, a brass collimator was developed and placed on the patient's surface. This work presents in-vivo dosimetry results and a phantom study to characterize the effects of the brass collimator.
Diagnosis. A 77-year-old male with multiple prior cutaneous SCC. The patient had prior radiotherapy with 60 Gy in 30 fractions to the scalp. The treatment was completed 12/29/2011. Current diagnosis revealed scalp SCC extending into fascia.
Treatment plan. A treatment plan was generated in Eclipse with a dose of 60 Gy in 30 fractions to the PTV. CBCT was order for each fraction. The plan utilized a 9 MeV beam, single field, 105 cm SSD, 249.6 MU, and a 15x15 cm2 electron aperture with custom electron block. In addition, a custom brass surface collimator was modeled in Eclipse and designed by .decimal. The bolus included 0.7 cm of brass and 0.5 cm of tissue equivalent material. The bolus was placed on the patient's surface within the treatment field.

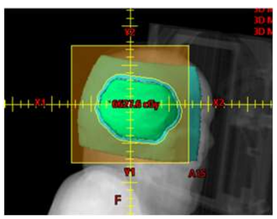

Figure 1. Beam eye field of the treatment field. Cyan blue: brass surface collimation. Green: silicon bolus

Methods and Materials

Phantom study. EBT4 films (10 cm x 2cm) that were calibrated beforehand were placed at the Varian head phantom surface (under 0.5 cm bolus for treatment) or at depth (under additional 1 cm bolus) at SI and AP direction with or without brass collimation as shown in figure 2. 24 hours after irradiation, the films were scanned with EPSON scanner and analyzed by Film QA pro. The dose profile was exported and plotted to compared the effect of brass collimation.

In-vivo dosimetry. On the first day of treatment, after CBCT imaging, we placed a strip of film (10cm x 2cm) under the brass collimation and treatment bolus at superior-inferior direction as shown in figure 2. 24 hours later, the film was scanned and analyzed. The dose profile was extracted and compared against Eclipse treatment planning system to verify the transmission factor and absolute dose.

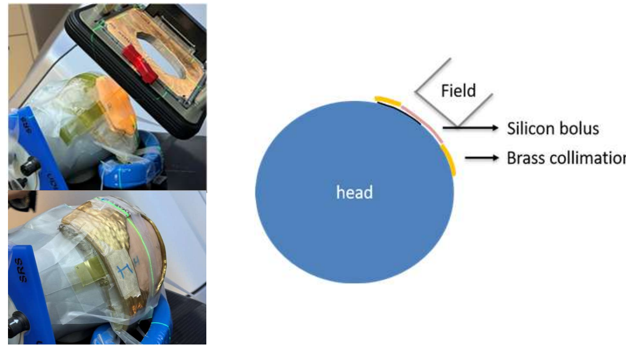

Figure 2. The setup of phantom study and in-vivo dosimetry. Upper left: phantom study without brass surface collimation. Lower left: phantom study with brass surface collimation. Right: In-vivo dosimetry setup with patient in prone position. The film strip was placed in SI-direction. The field edge was marked on the film for further comparison and analysis. In addition, the film was placed partially underneath the silicon bolus and partially underneath the brass collimation.

Results

Phantom study. The profile of the films from the phantom study at the surface and at depth are shown in figure 4. We confirmed that the penumbra was reduced with the brass bolus. It was also demonstrated that the transmission factor of 0.7 cm brass is close to 0 for 9e electron beam both at the surface and at depth, which is consistent with the previous literature. Of note, the spikes (see orange lines in figure 2) might come from the additional 0.5 cm margin for the treatment field.

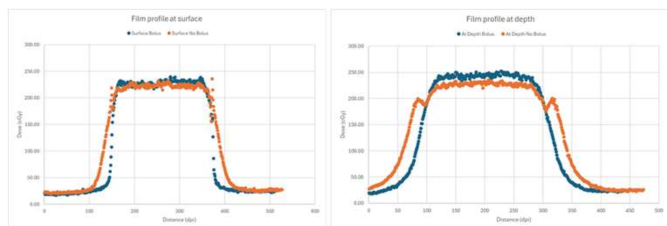

Figure 2. Film profile at the surface (left) and at depth (right). The penumbra was reduced significantly at the surface.

In-vivo dosimetry. The film reading (209 cGy) showed agreement to the treatment planning system (210 cGy). We also compared the profile of the film to the dose profile on Eclipse. The film reading and profile results are consistent with the treatment planning system with a reduction in penumbra. This demonstrated the feasibility of utilizing brass shield to reduce radiation dose to nearby normal tissues.

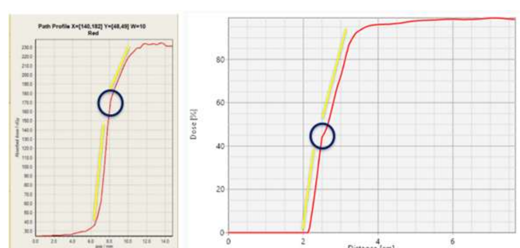

Figure 3. Film profile from in-vivo dosimetry (left) and the dose profile reported from treatment planning system (right).

Discussion

In this study, we utilized the film dosimetry to verify the transmission factor and dose falloff profile with the brass collimation. This was not only conducted on the phantom but also applied for patient treatment.
The film profile from the phantom study showed that the effect of brass collimation on dose falloff at depth was not as profound as that at surface. This might put a limitation on the application of brass collimation.
The patient eventually ended the treatment course earlier. Thus far, we are still not sure if it was a result from the re-irradiation or disease progression.

Conclusions

This is the first in-vivo dosimetry study on brass shield as a skin collimation tool for electron beam therapy. Brass surface collimation can be a useful tool to reduce the penumbra at the filed edge and minimize the dose to nearby superficial normal tissue.
This work showed the effectiveness of brass collimation by conducting phantom study and in-vivo dosimetry. A reduction in penumbra and sharper dose falloff was observed by using film dosimetry.

Reference

Herchko SM, Rutenberg MS, Beltran CJ, Yaddanapudi S. Technical note: A comparison of in-house 3D-printed and commercially available patient-specific skin collimators for use with electron beam therapy. J Appl Clin Med Phys. 2024; 25:e14366. https://doi.org/10.1002/acm2.14366

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