Brass Eye Shields for Total-Skin Electron Therapy

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Abstract

Purpose: To confirm leaded brass as a shielding alternative to Cerrobend for eye shields during total-skin electron (TSE) radiotherapy treatments.

Methods: 1.5 cm thick leaded-brass inserts were fashioned from patient-specific lung blocks from .decimal. Inserts were placed inside of swimming goggles as eye shields for TSE treatments utilizing 2.5 MeV electrons. With a density of 8.4 g/cm^3, the electron range in the brass is expected to be 1.5 mm. With an effective attenuation coefficient of 0.0392 cm^2/g, the half value layer of the brass is approximately 2.1 0cm, reducing the photon contamination to 61%.

The goggles were placed on a RANDO head-and-neck phantom and positioned with clinical setup. Gafchromic EBT4 film was placed (1) on the front goggle face, (2) between the goggles and the brass, and (3) behind the brass. The phantom was irradiated under treatment conditions: six orientations with two gantry angles for each orientation, 70° and 110°, to a total of 120 cGy to the patient's skin. This irradiation was repeated three times and the films in locations 1 through 3 were compared to reference film (4) that was irradiated on the phantom without shielding. Films were read after 24 hours with both prescan and background subtraction. Data was also collected on a single patient.

Results: Average dose for film location 1 was 108 cGy, location 2 was 114 cGy, location 3 was 13 cGy, and location 4 was 94 cGy for the RANDO phantom. Average dose for location 1 was 147 cGy, location 2 was 130 cGy, location 3 was 23 cGy, and location 4 was 118 cGy for the patient. The shielding reduced the dose to film 3 by an average of 83% relative to the reference film. Experimental measurements showed a greater reduction than the calculations as the calculations assumed perpendicular incidence, an infinitely wide shield of uniform thickness, a monoenergetic beam, and did not account for air attenuation.

Conclusions: This work shows the viability of reusing brass from lung blocks as eye shields for TSE treatments. Differences between the RANDO phantom the patient data are most likely due to the inability to get a tight-fitting seal with the goggles on the phantom and patient setup. Additional patient data is being collected. Using brass instead of Cerrobend for TSE treatments increases safety for therapists and patients while also limiting waste.

Introduction

Total skin electron irradiation is used to treat a variety of skin ailments, particularly mycosis fungoides. Cerrobend has long been used as a radiation shielding material to protect the patient's eyes, but the toxicity of the material creates hazards for patients and clinic staff. Reusing brass from patient-specific lung blocks from total-body irradiations to create eye shields for total-skin electron treatments removes the need for the toxic Cerrobend while still providing shielding for the patient's eyes.

Materials and Methods

Leaded brass lung blocks from total-body irradiation patients who had completed treatment were refashioned into oval blocks about 1.5 cm thick that fit in the eyes of standard swim goggles. Elemental composition of the blocks is given in Table 1.

Patients are treated using an Elekta Versa linear accelerator with an average electron energy of 2.5 MeV at the patient. As the brass has a density of 8.4 g/cm^3, the electron range through the eye shields for this energy is approximately 1.5 mm. With an effective attenuation coefficient of 0.0392 cm^2/g for 2.5 MeV photons, the half value layer of the brass is approximately 2.10 cm, meaning the shields should reduce the photon contamination to 61%, considered adequate due to the limited amount of photon contamination present initially.

Measurements were taken with the goggles on a RANDO head-and-neck phantom as shown in Figure 1b and on a patient. Three squares of Gafchromic EBT4 film were placed at each of four locations: outside of the goggles (location 1), between the goggle lens and the brass block (location 2), and behind the brass block (location 3). Location 4 acted as a reference and was either on the phantom's eyes without goggles present during a subsequent irradiation or on the patient's cheek during their treatment. The layers of the materials in the goggles are showing in Figure 1a.

The phantom and the patient were treated in 6 positional orientations with two gantry angles for each orientation: 70° and 110° to deliver a total dose of 120 cGy to the skin. Doses to the film were measured using an EPSON 10000XL flatbed film scanner 24 hours after irradiation and utilized both prescan and background subtraction.

Table 1. Relative composition data and associated x-ray mass attenuation coefficients at 2.5 MeV for the brass.[1]

Material	Relative Composition	Attenuation Coefficient (cm^2/g)
Copper	60% [55% - 65%]	3.902×10^{-2}
Zinc	37.5% [31.5% - 43.5%]	3.934×10^{-2}
Lead	2.5% [1.5% - 3.5%]	4.420×10^{-2}

Table 2. Measured dose in cGy for different locations of film and dose normalized to the direct dosage either to the phantom's eye or the patient's check. Uncertainties listed are standard deviations of the mean.

Film Location	Patient	Measured Dose (cGy)	Dose Relative to Direct
Front of Goggles (Location 1)	RANDO	108.2 ± 1.7	1.15
	Patient 1	147.1 ± 4.5	1.22
Between Goggle Lens and Shielding (Location 2)	RANDO	114.3 ± 9.4	1.21
	Patient 1	130.0 ± 9.4	1.04
Behind Shielding (Location 3)	RANDO	13.1 ± 3.2	0.14
	Patient 1	22.6 ± 11.6	0.19
Direct on Eye or Cheek (Location 4)	RANDO	94.4 ± 5.8	N/A
	Patient 1	118.2 ± 3.2	N/A

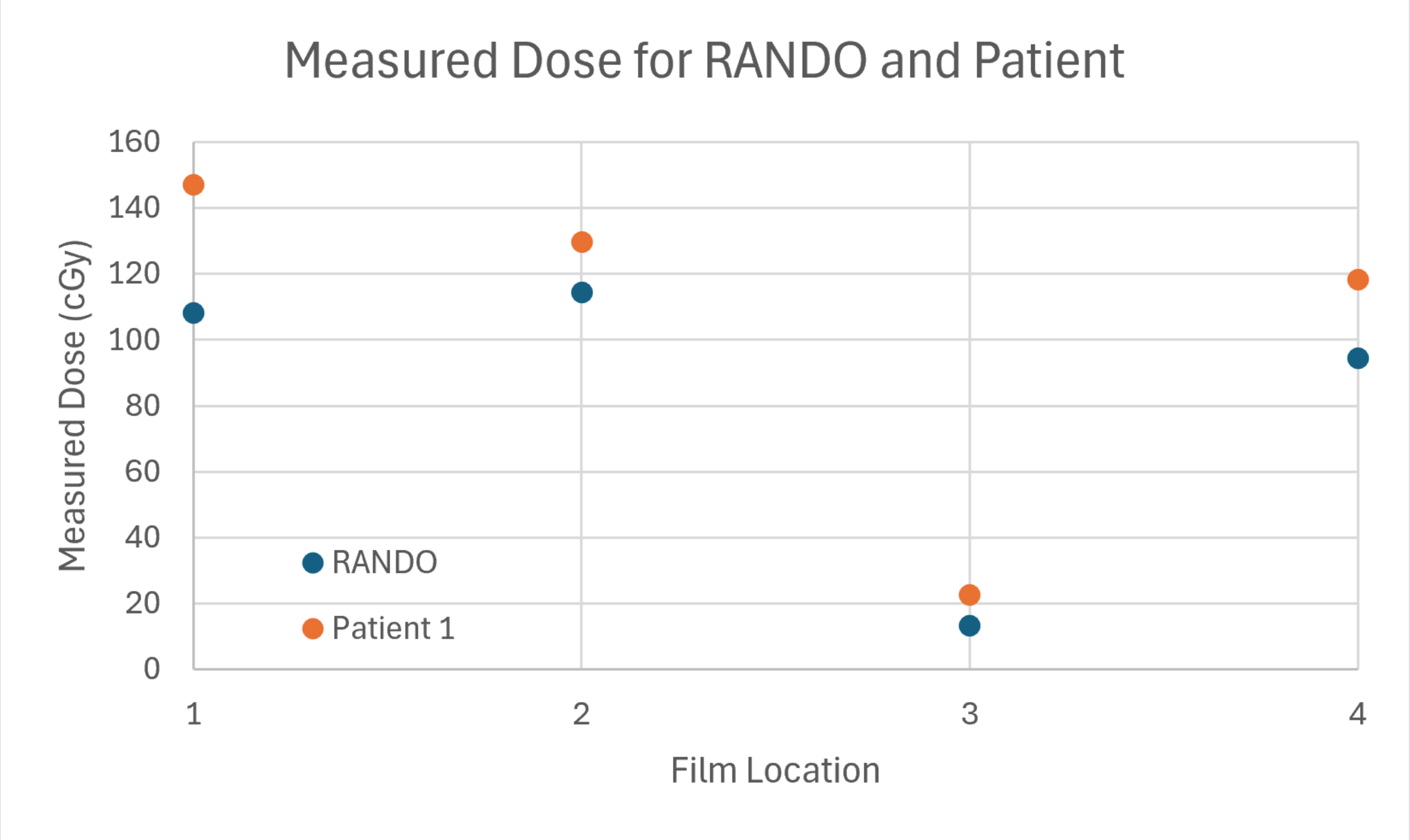

Figure 2. Comparison of measured doses between the same locations on the RANDO phantom and on the patient.

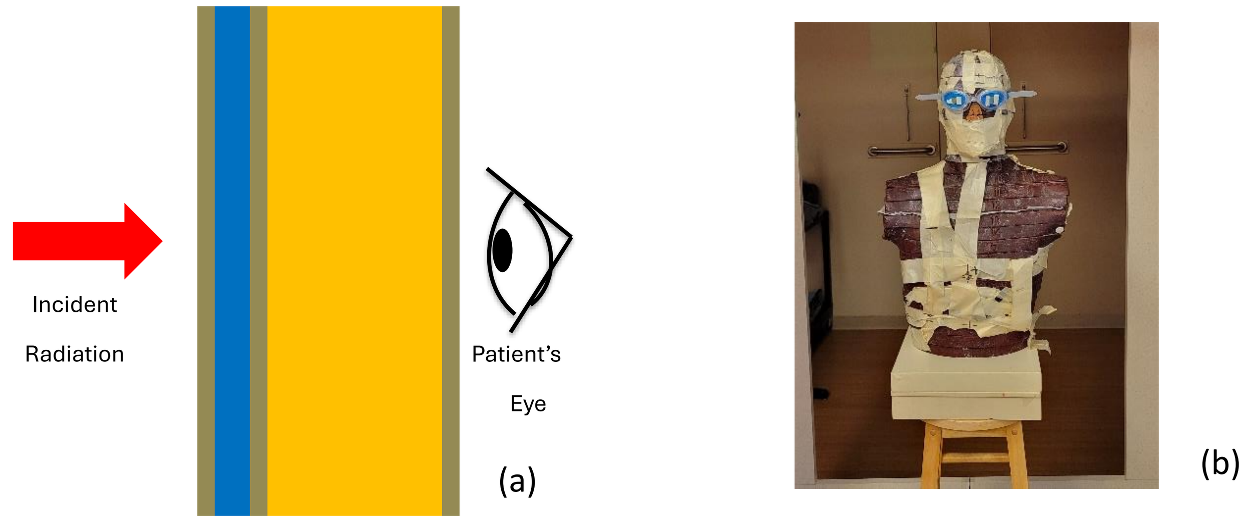

Figure 1. (a) Diagram showing layers of film (brown), swim goggle lens (blue), and brass shielding (orange). Figure is not to scale. (b) Experimental setup showing the shielded goggles placed on the RANDO head-and-neck phantom.

Results

Average doses for both the RANDO phantom and patient measurements are given in Table 2 and Figure 2. The doses in Table 2 are also shown as normalized to the dose received directly to either the phantom's eye or the patient's cheek.

Discussion

Measurements with both the RANDO phantom and the singular patient showed a substantial decrease in the measured dose behind the brass shields, to approximately 17% of the unshielded dose. The RANDO phantom showed a lower-than-expected dose for the direct-on-eye measurements which is believed to be caused by the eyes being slightly recessed into the phantom meaning they were more shielded by other parts of the phantom than the film on the patient's cheeks.

Differences between the RANDO phantom and the patient are likely due to the inability to get a tight-fitting seal with the goggles on the phantom as well as variation in the exact patient setup in addition to potential patient movement during the irradiation.

Conclusions

This work shows the viability of reusing brass from lung blocks as eye shield for total-skin electron treatments. Experimental measurements showed a greater reduction than the analytical calculations as the calculations assumed perpendicular incidence, an infinitely wide shield of uniform thickness, a monoenergetic beam, and did not fully account for air attenuation. Additional patient data is being collected to allow for better statistical analysis.

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References

1. Hubbell, J. H. and Seltzer S. M. X-Ray Mass Attenuation Coefficients. 2004. https://www.nist.gov/pml/x-ray-mass-attenuation-coefficients