Lens Dose to Standing Patients Treated With Electrons to the Hand

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INTRODUCTION

Patients treated with electrons to the hand while standing beside the applicator have a line of sight from their eyes to irradiated surfaces. Their lenses will receive some amount of dose from electrons backscattered from the applicator, the block, or their hand.

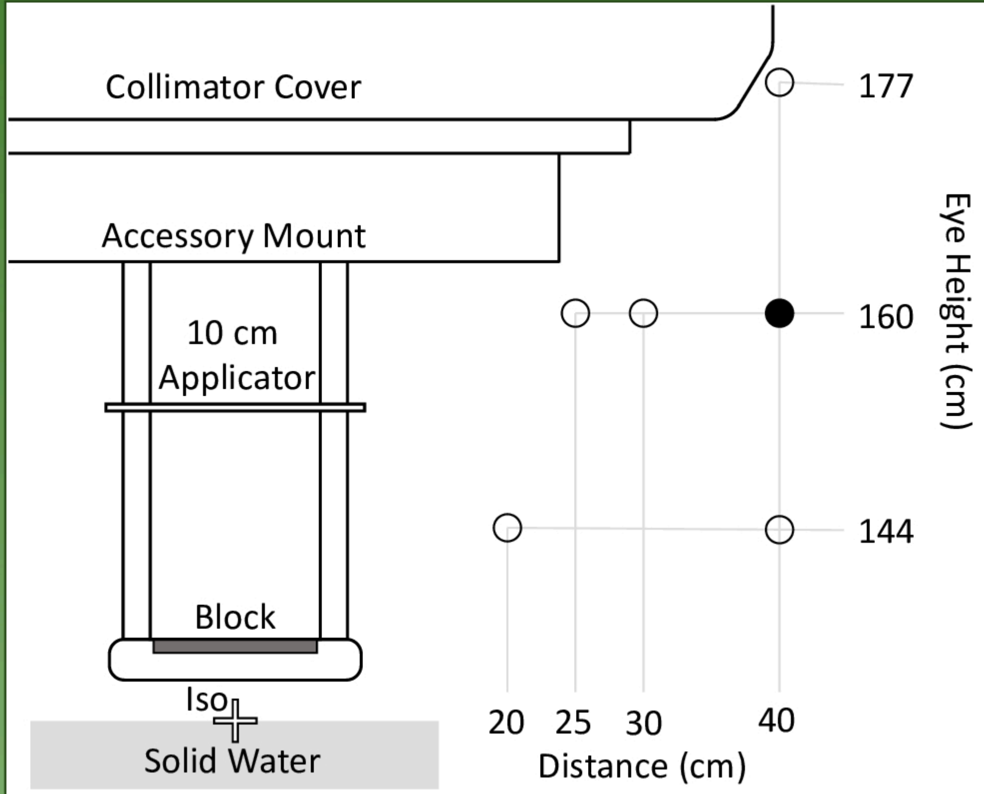
There does not appear to be a threshold dose for cataract development and no measurement of this source of lens dose was found in the literature. This work seeks to quantify the lens dose as a function of several treatment parameters to estimate risk and to determine the effectiveness of some practical mitigation strategies.

METHODS

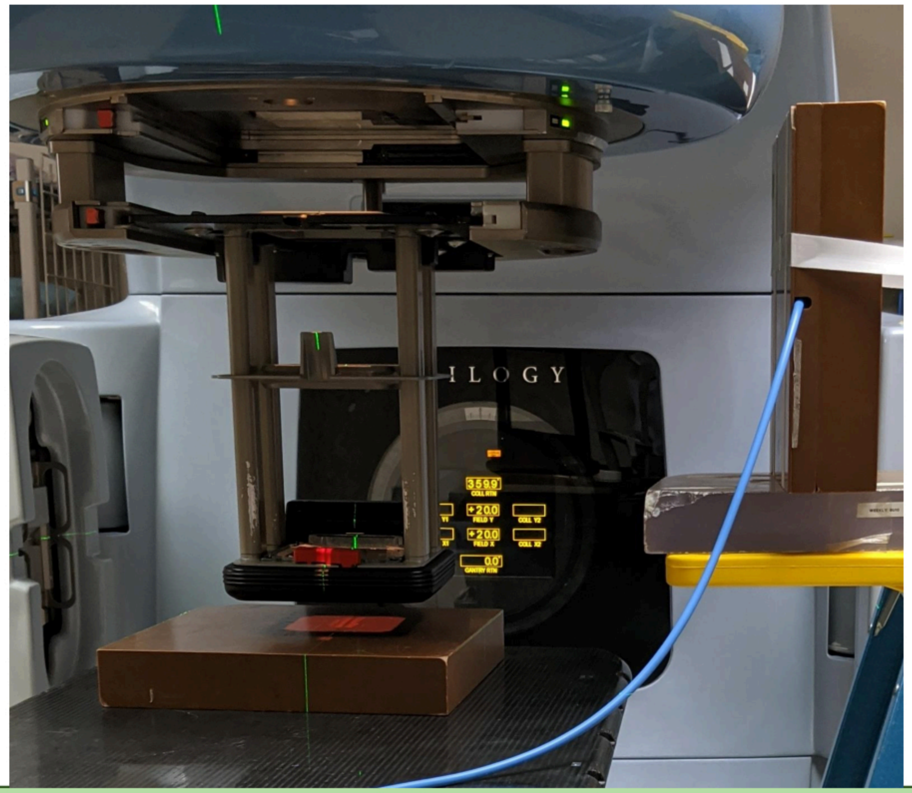
Dose was measured in two phantoms at a depth of 3 mm as a surrogate for lens dose[1]. A Varian Trilogy linear accelerator was used.

For investigation of trends in lens dose with eye height, lateral eye distance, beam energy, applicator size, block fill, and depth in patient, measurements were made with a PTW Advanced Markus-type parallel plate chamber in solid water, mounted beside the applicator and facing horizontally toward it. Each parameter was varied separately from a basis setup of 160 cm above the floor, 40 cm lateral from the beam axis, a 9 MeV beam; a 10 cm applicator; and a solid cerrobend block without cutout.

For appropriate mitigation strategies dose was measured with Landauer nanoDot OSLDs placed on the eye of an anthropomorphic Rando head phantom and covered in 3 mm of soft bolus. The setup was otherwise the same as the basis setup above.



Locations of measurements positions beside the electron applicator. The black point is the basis setup from which other parameters are varied, photographed below with the Markus chamber setup.



Lens Dose / Nominal Treatment Dose

Eye Height (cm)		Applicator Size (cm)		Lateral Distance (cm)	
144	0.13% ± 0.03%	6×6	0.11% ± 0.03%	**40**	**0.15% ± 0.01%**
160	**0.15% ± 0.01%**	**10×10**	**0.15% ± 0.01%**	30	0.24% ± 0.03%
177	0.03% ± 0.03%	15×15	0.19% ± 0.03%	25	0.53% ± 0.04%
		20×20	0.59% ± 0.04%	20*	0.83% ± 0.06%

*at 144 cm height for clearance

Energy (MeV)		Block Size and Fill		Depth (mm)	
6	0.13% ± 0.03%	**10x10 Solid**	**0.15% ± 0.01%**	0	0.19% ± 0.03%
9	**0.15% ± 0.01%**	10x10 6 cm Circle	0.12% ± 0.02%	**3**	**0.15% ± 0.01%**
12	0.11% ± 0.03%	10x10 Open	0.08% ± 0.03%	4	0.15% ± 0.01%
16	0.08% ± 0.03%	20x20 Solid	0.59% ± 0.04%		
20	0.05% ± 0.03%	20x20 Open	0.13% ± 0.03%		

Measured doses in parallel plate chamber per unit dose treated (MU). The bold values are the basis setup shown in the upper figure.

Mitigation Technique Effect

Head Rotation		Shielding	
90 deg to side	28% ± 2%	Eyes closed	100% ± 10%
180 deg to side	2.2% ± 0.2%	1 mm Pb glasses	32% ± 3%
45 deg up	40% ± 3%	2 mm Pb glasses	23% ± 2%
45 deg down	118% ± 9%	1 mm Pb on cone	<7%

Measured doses with each mitigation technique vs without. Data are on head phantom with OSLD except for those with eyes closed and cone shielding.

CONCLUSIONS

A typical setup for a 50 Gy course would typically deliver approximately 8 cGy to the lens without mitigation, increasing to 46 cGy for a patient leaning in toward the applicator, and potentially even higher with large fields.

Doses as low as 10-25 cGy have been shown to detectably increase lifetime cataract risk[2-5], so it is worth reducing this dose if reasonably achievable.

Actions as simple as turning the head to the side eliminate nearly ¾ of the dose to the lens of the proximal eye. When feasible, turning completely away would virtually eliminate the dose. Glasses covered in 1-2 mm lead are also effective.

Most importantly, patients should be dissuaded from leaning in to watch the treatment, as some naturally want to do.

REFERENCES

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