

Introduction: Recent reductions in the threshold of absorbed dose to the eye by the International Commission on Radiological Protection (ICRP) to 500 mGy indicate the need for elevated awareness of tissue reactions that lead to cataracts (1). Many Neuro CT scans, such as perfusion-CT and CT-angiography performed on stroke patients, have the potential of delivering high doses to the lens of the eye. Our goal was to design a process to clinically monitor eye dose during Neuro CT scans and use this process to assess the respective contributions to the total absorbed dose to the eye by the different components of stroke CT workups.

Material and Methods: Eye entrance exposure measurements were made using InLight® nanoDot™ dosimeters from Landauer, Inc. (Glenwood, IL). These nano-dosimeters use an optically stimulated luminescent (OSL) detector composed of carbon-doped aluminum oxide ($Al_2O_3:C$). The outside dimension of the dosimeter is $10 \times 10 \times 2$ mm³. Their response is linear up to 3 Gy, with an energy range of 5 keV to 20 MeV. The dose measurement accuracy of the dosimeters is $\pm 5.0\%$. These nano-dosimeters have no angular or energy dependence making them ideal for both measuring doses to curved surfaces, such as the eye, as well as anatomy both in and out of the field. For all measurements, nano-dosimeters were taped on an in-house anthropomorphic head phantom either at the position of the eye lens or at the outside corner of the eye (Figure 1). The phantom was scanned using a typical stroke CT protocol. The first part of the study compared the total entrance exposure at the lens of the eye to that measured at the corner of the eye to verify similar exposures at these two locations, hopefully avoiding having to place the nano-dosimeters directly on the patient’s eye for clinical use. In the second part of the study, we separately evaluated three components used for a stroke CT workup: scout + non-contrast head, perfusion sequence, and CT-angiography (CTA) + post contrast head (Table 1). For each phase of the protocol, entrance exposure measurements were only made at the corner of the eye since little differences were observed during part 1 of the study.



Figure 1: Head phantom with nano-dosimeters placed at lens and corner of the eye.

Table 1: CT stroke protocol

Phase of Protocol	CT Scan Details
1	scouts, non-contrast head
2	perfusion (2 levels)
3	CTA, post contrast head

Results: The results from parts 1 and 2 of the study are summarized in Figure 2. The total entrance exposure for the eye lens was 88 ± 5.9 mGy compared to 87 ± 3.8 mGy at the corner of the eye. The measured entrance doses for the 1st, 2nd, and 3rd phases of the protocol were 25 ± 0.2 mGy, 24 ± 1.8 mGy, and 58 ± 2.4 mGy, respectively.

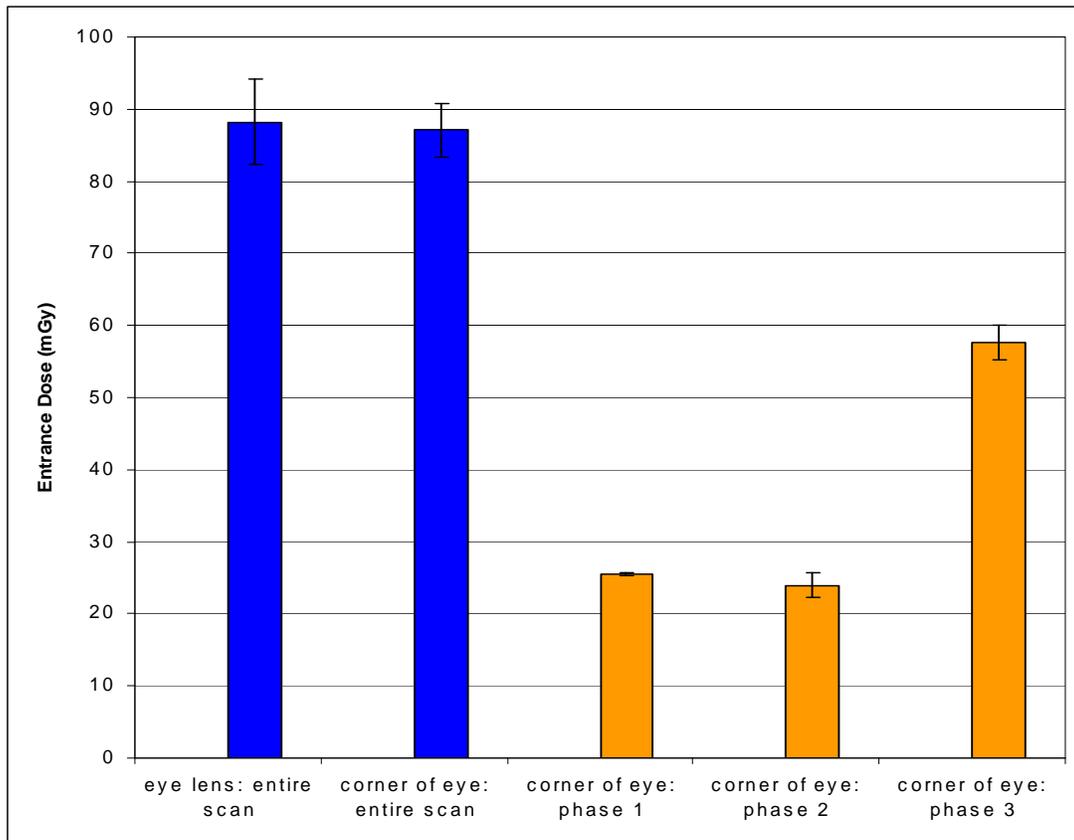


Figure 2: Eye entrance exposure measurements for part 1 (blue) and 2 (orange) of the study.

Discussion: The results showed good agreement between the measured exposure to the eye lens and the corner of the eye indicating that the corner of the eye is a viable alternative to direct eye lens measurements. The CTA component of the stroke CT workup contributed more than half of the total eye dose delivered by the stroke CT protocol, while the non-contrast CT and the perfusion CT contributed equivalent, yet smaller doses. Although perfusion CT has been associated with alopecia (2), it appears that the CTA portion, for this particular protocol, could be adding similar risk for the eyes. Monitoring of cumulative eye dose for patients undergoing serial studies for stroke evaluation may aid in the planning of sub-threshold levels for cataracts when possible.

References:

¹ICRP ref 4825-3093-1464

² Y. Imanishi, A. Fukui, H. Niimi, et al., "Radiation-induced temporary hair loss as a radiation damage only occurring in patients who had the combination of MDCT and DSA," *European Radiology* 15-1 (2005).