Characterization of Optically Stimulated Luminescence Dosimeters in a simulated Fluoroscopy Beam

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Introduction

Previously, an overall characterization of the nanodot OSLDs by Landauer, Inc. was performed including an assessment of the angular response of a fluoroscopy beam with respect to a line perpendicular to the surface of the nanodot. The methodology used was modeled after a previous angular assessment in CT; however, other nanodot OSLD characterization studies[1,2] revealed that the previous CT characterization methodology may not have been sufficient. The other characterizations (Figs. 1,2) evaluated angular dependence from 0-360º, whereas the previous characterization (Fig. 3) only investigated 0-90º and assumed a symmetric response. Furthermore, the previous investigation exposed nanodots in air and at the center of a cylindrical phantom (Fig. 3), but it never investigated nanodot response on the surface of a phantom.

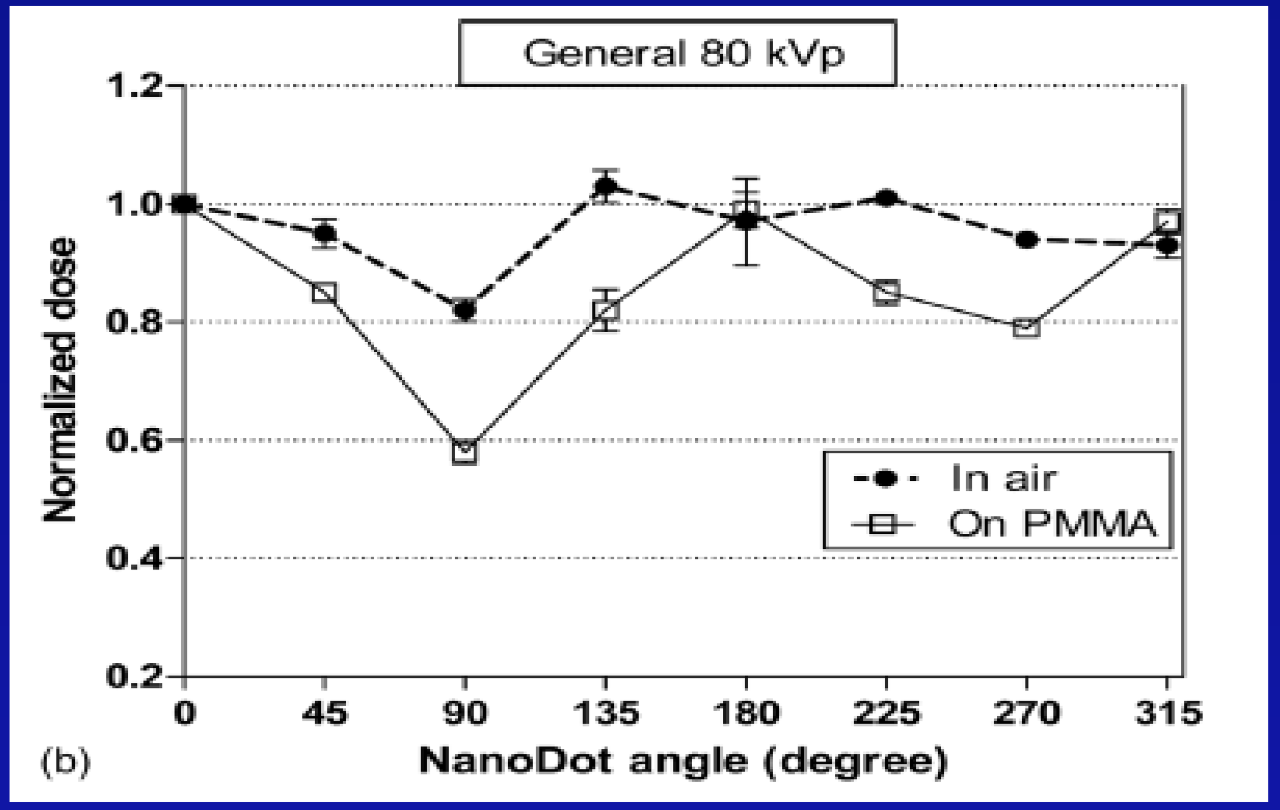

Fig. 1 Results from Al-Senan's characterization of nanodots in general diagnostic energy range from 0-315º at cardinal angles. Dose is normalized to 0º.[1]

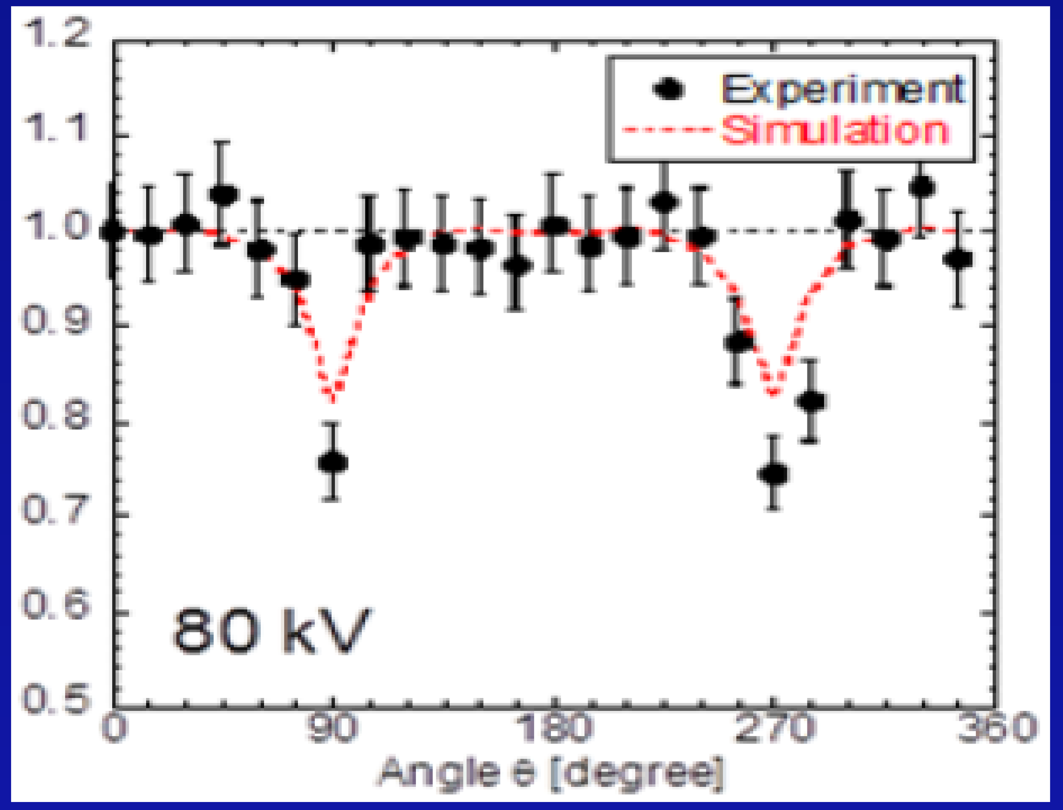

Fig. 2 Results from Okazaki's characterization of nanodots for skin dose measurement from 0-360º.[2]

Methods

For this experiment, a sheet of paper was wrapped around one side of a cylindrical phantom while a protractor was placed with the center of its zero-edge on the center of one of the circular sides of the phantom to allow the paper to be marked at the cardinal angles, (0-180º). Two strips of tape were placed on the paper and two nanodots were aligned with each mark with one of the two strips having ~~all~~ the nanodots "barcode side" up and the other with the "barcode side" down so as expose the full 360º. Three sets of these strips (Six in total) were made so as to average the doses measured by six different nanodots at each mark. One strip of barcode side up and one strip of serial number-up nanodots were placed on the previously mentioned cylindrical phantom and were exposed to a simulated fluoroscopy beam at 80 kVp (Fig. 4). This was repeated for the other two sets of nanodot tape strips. The distance from the focal spot to the closest nanodot to the focal spot (0º) was measured so as to calculate a distance correction factor for each nanodot to the 0º spot. The setup was oriented so that the strips laid perpendicular to the anode-cathode axis of the x-ray tube.

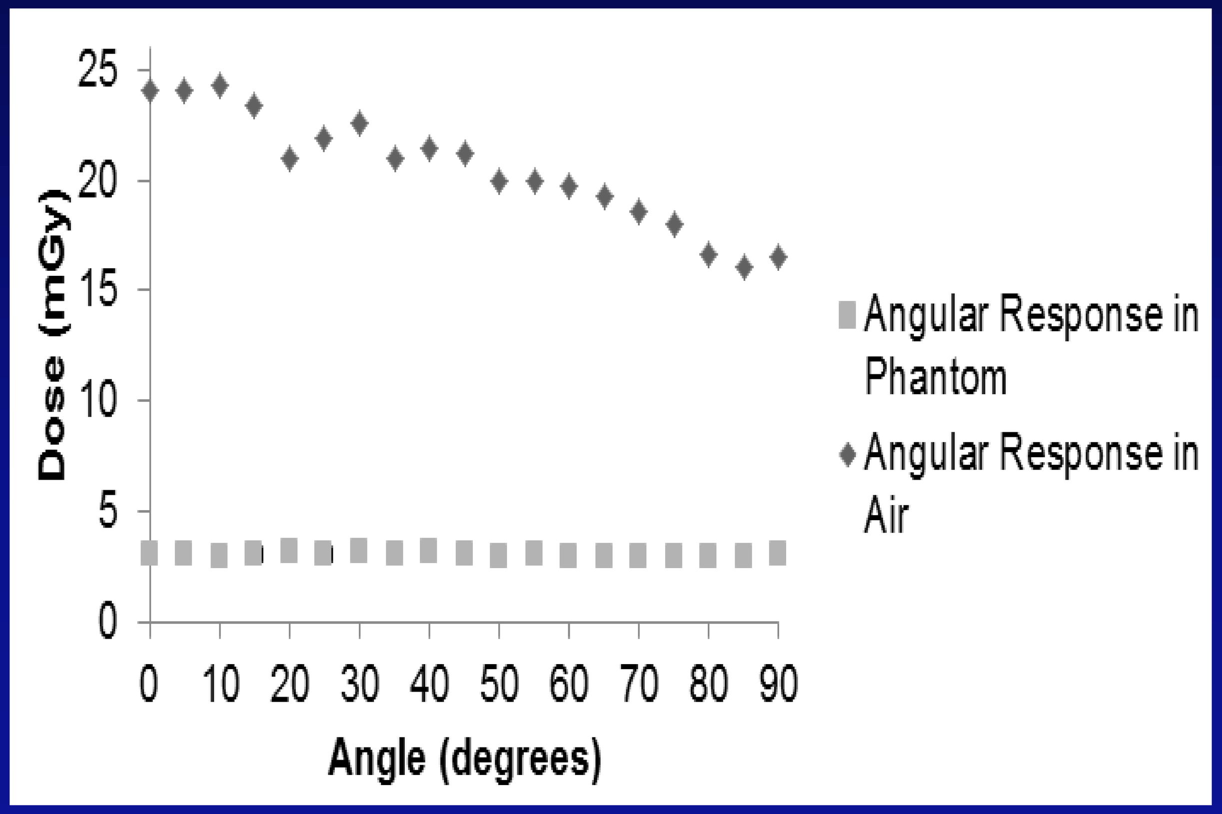

Fig. 3 Previous results in Air and in Phantom showing dose to nanodots with the CT beam angled. Assumed symmetric response.[3]

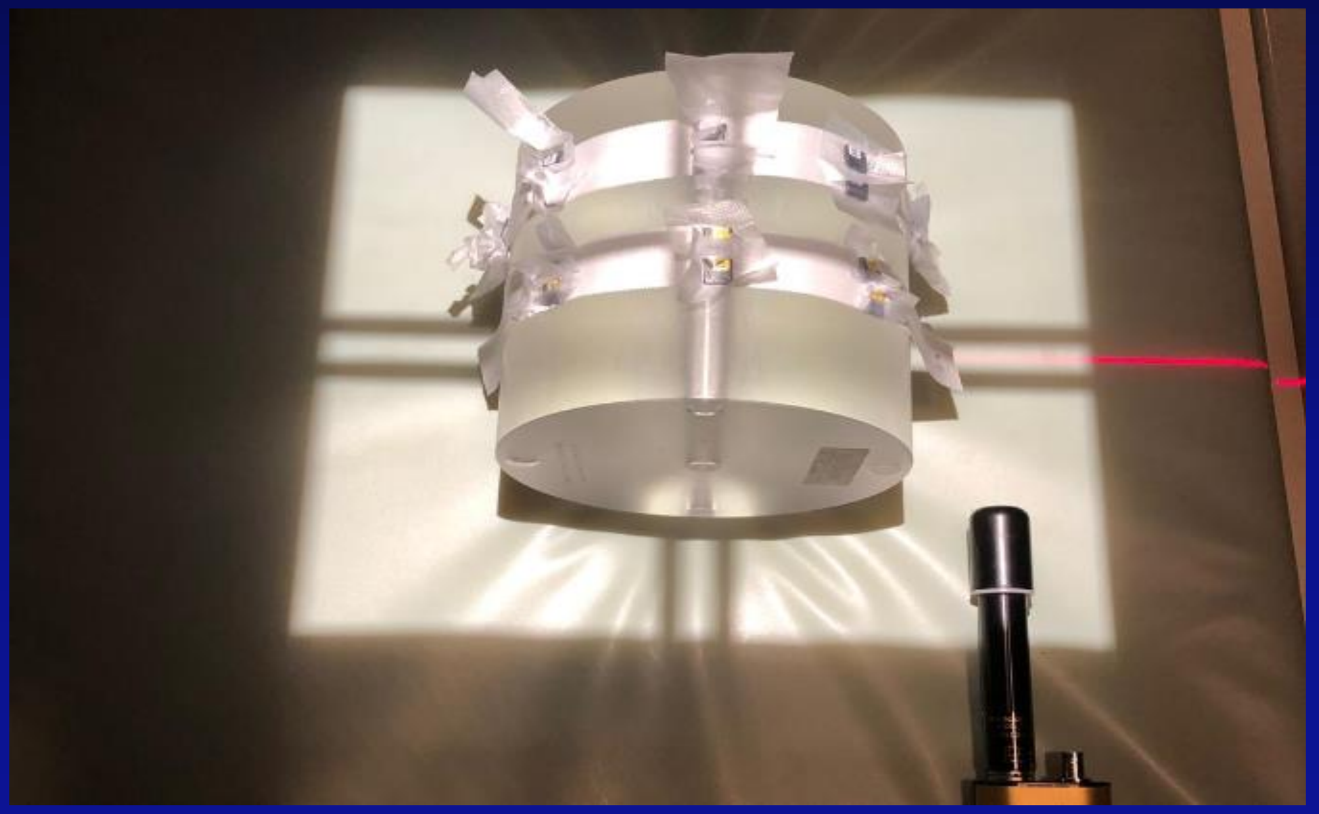

Fig. 4 The new experimental setup viewed from above. Two strips of nanodots on a cylindrical CTDI phantom with a 6 cc ion chamber for exposure consistency monitoring

Results

In Fig.5 are the results from the three exposures. The nanodots under-responded the most at 90º and 270º with the greatest being the latter at 20% below. All nanodots were corrected for the beam quality used.

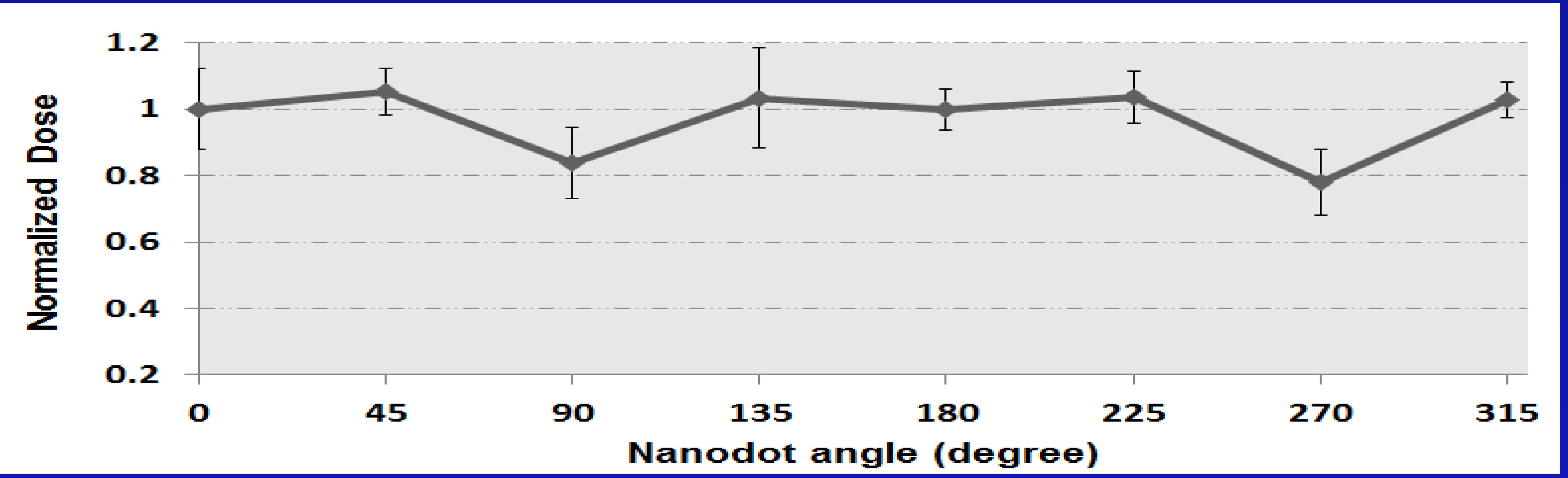

Fig. 5 Dose normalized to 0º versus nanodot angled with respect to the simulated fluoroscopy beam.

Conclusions

1.) Nanodots behaved similarly to the previous characterizations in the 90º and 270º locations.
2.) For 90º, the nanodots did not under-respond as much to the simulated fluoroscopy beam versus in the general diagnostic beams and simulations of the previous studies.
3.) Correction factors can be calculated to account for these angular dependencies during clinical use.

References
1. Al-Senan, R.M., et.al, Characteristics of an OSLD in the diagnostic energy range, Med. Phys. 38 (7), July 2011
2. Okazaki, T., et.al, Fundamental Study of nanoDot OSL Dosimeter for Entrance Skin Dose Measurement in Diagnostic X-ray Examinations, Journal of Radiation Protection and Research 2016; 41(3):229-236