J of Nuclear Medicine Technology, first published online June 9, 2020 as doi:10.2967/jnmt.120.243345

A Comparison of Radiation Exposure Readings of Thermoluminescent Dosimeter Ring Badges When Worn in Different Positions

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Abstract

The purpose of this research was to evaluate whether the position of a thermoluminescent dosimeter crystal (TLD) results in different exposure rates. **Methods:** Nine subjects wore two TLD badges (one inward facing and one outward facing) for two months. Both TLDs were worn on the dominant hand on the middle finger with the TLD facing inward placed on the bottom and the outward facing TLD placed on top. At the end of the first month both TLDs were turned in and they were given two new TLDs. Combined results from the badges for the two months were recorded in millisieverts. A paired t-test with two sample means was performed comparing positions, for general nuclear medicine and PET/CT subjects, with an alpha of 0.05. **Results:** For all subjects and for general nuclear medicine and PET/CT groups, mean exposure was greater on the inward-facing TLD. **Conclusion:** Maximum extremity exposure readings for TLDs worn on the dominant hand are seen when the TLD is worn facing in toward the palm.

Keywords: Crystal, Position, Thermoluminescent Dosimeter (TLD), Exposure rates, Radiation

Introduction

Radiation workers wear thermoluminescent dosimeters (TLDs) to monitor their extremity radiation exposure. TLDs should be worn on the dominant hand facing inward (toward the palm) because it provides accurate feedback when measuring exposure to the extremities (*1*) (*2*). Regular monitoring is important to prevent receiving the maximum annual exposure limit. The annual exposure limit of the extremities is 500 millisieverts (*1*).

A previous study was conducted with two technologists over a period of 16 months (3). The technologists wore two TLDs on their dominant hand with one placed inward toward the palm (anterior) and the other placed outward, away from the palm (posterior). The purpose of this study was to determine if there was a difference in exposure to the anterior and posterior side of the finger (*3*). Results from their study indicated that the TLD facing out resulted in equal or greater exposure to the finger. This study had several limitations. First, only two radiation workers were used. Second, only exposure from general nuclear medicine was used. Third, it was not stated how the TLD's were worn by the technologist.

Radiation workers may not be consistent in how they wear their TLDs. TLDs can be worn with the crystal facing inward toward the palm or with the crystal facing outward away from the palm. The best way to wear a TLD is whichever way will result in the maximum exposure. Working in PET may yield a higher radiation exposure compared with general nuclear medicine due to working with an increased energy of 511-keV compared to 140-keV (*4*). In PET, the highest contributor in exposure to the extremities comes from dose administration (*5*). The most exposure in general nuclear medicine comes from the preparing the dose (*2*). The purpose of this research was to evaluate whether the position of a thermoluminescent dosimeter

crystal results in different exposure rates. This study includes subjects that worked in both general nuclear medicine and PET/CT.

Materials and Methods

Institutional review board approval was obtained prior to this study. This was a prospective study and nine radiology workers were solicited to participate as subjects. The subjects were divided into two groups: general nuclear medicine and PET/CT. Six of nine the nine subjects were in general nuclear medicine, and three subjects were in PET/CT. Eight subjects were right-hand dominant and one subject was left-hand dominant. A total of eighteen data points was used for the study. A paired two-sample t-test was used with an alpha of 0.05 to indicate statistical significance. The results were recorded in millisieverts for all subjects.

For the study, materials included: 54 lithium fluoride ring badges from Landauer and dosimetry reports. Each subject wore two TLDs: TLD one was worn with the crystal facing in towards the palm (inward facing), and TLD two was worn with the crystal facing out toward the back of the hand (outward facing). Both TLDs were worn on the subjects' middle finger of their dominant hand. The inward facing TLD was worn on the bottom and the outward facing TLD was worn on the top (Figure 1). The TLDs were worn for one month. This process was repeated for a second month. At the conclusion of each month, the TLDs were sent to Landauer for reading.

Results

The mean exposure of the inward facing TLD was 1.84 mSv and the mean exposure of the outward facing TLD was 1.26 mSv (Table 1). For general nuclear medicine, the inward facing TLD had a mean of 1.27 mSv and the outward facing TLD had a mean of 0.93 mSv

(Table 1). For PET/CT, the inward facing TLD had a mean of 2.97 mSv and the outward facing TLD had a mean of 1.92 mSv (Table 1). In general nuclear medicine, the TLD facing inward almost always had higher exposure compared to the TLD facing outward (Table 2). In PET/CT the TLD facing inward always yielded the highest exposure compared to the TLD facing outward (Table 2).

For all subjects, a p-value of 0.0013 was obtained when comparing the inward facing and the outward facing TLD badges.

Discussion

Results from this study showed there was a statistically significant difference in exposure readings when comparing inward and outward-facing TLD positions. This occurred for both general nuclear medicine and PET/CT. These findings are important because radiation workers should wear TLDs in whichever way that will receive the maximum exposure. When the TLD is worn on the dominant hand, the inward facing position yields the highest reading.

A previous study done concluded the TLD positioned facing outward resulted in higher exposure rates (*3*). This is the opposite of my conclusion which is maximum exposure reading is obtained when the TLD is placed inward. The results could be different due to this study using more subjects. Exposure readings from PET/CT was also included in this study, rather than only general nuclear medicine.

There were several limitations that could potentially be avoided if future research were to be done. One limitation was that it was hard to keep the TLDs positioned in the same spot throughout the entire day. Ring badge position can change while donning gloves. The TLD position may also change if a radiation worker has a habit of spinning their ring or switching to another finger. In addition, having the outward facing ring on the top and the inward facing ring

on the bottom could have had a minor effect on the results due to a slight difference in location on the finger itself. Another limitation was a limited amount of time to collect data (two months) and a small sample size (18 data points).

Further research of TLD positioning should be conducted with more subjects over a longer period, controlling rotation of the rings, as well as placement (top vs bottom). Data should include both general nuclear medicine and PET/CT to account for the higher extremity exposure in PET/CT.

Conclusion

Maximum extremity exposure readings for TLDs worn on the dominant hand are seen when the TLD is worn facing inward toward the palm.

References

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Table 1: Comparison of Inward and Outward Facing TLDs Exposures (mSv) in General Nuclear Medicine and in PET/CT, with t-test

	Inward		Outward		P(T<t) Two-Tail
	Mean	Variance	Mean	Variance	
All Subjects	1.84	2.59	1.26	1.09	0.00
General Nuclear Medicine	1.27	1.17	0.93	0.75	0.00
PET/CT	2.97	3.93	1.92	1.27	0.03

Table 2: Exposures of Inward and Outward Facing TLDs in General Nuclear Medicine and in PET/CT in Millisieverts

Asterisk: Left-Hand Dominant

General Nuclear Medicine	Inward	Outward
1	2.13 mSv	2.19 mSv
2	1.22 mSv	0.89 mSv
3	0.42 mSv	0.23 mSv
4	0.25 mSv	0.13 mSv
5	1.94 mSv	1.50 mSv
6	3.61 mSv	2.53 mSv
7	0.67 mSv	0.34 mSv
8	2.38 mSv	1.74 mSv
9	0.92 mSv	0.42 mSv
10	1.53 mSv	1.05 mSv
11	0.24 mSv	0.20 mSv
12*	0.00 mSv	0.00 mSv
PET/CT		
13	2.65 mSv	2.00 mSv
14	3.99 mSv	2.41 mSv
15	6.48 mSv	3.90 mSv
16	1.50 mSv	1.02 mSv
17*	1.17 mSv	0.91 mSv
18	2.07 mSv	1.29 mSv

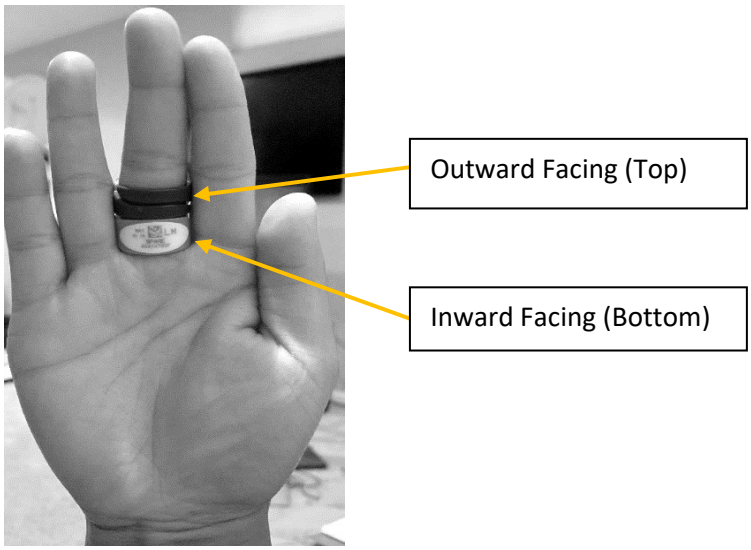

Figure 1: Position of TLDs