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## **Assessment of staff of radiology department annual effective doses during bone scans**

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**Abstract**--Background: The most frequent imaging techniques used by NM departments are skeletal scintigraphy and bone scans. To assess the protective measures and the anticipated radiation hazards, it is crucial to evaluate the patient's doses for the NMC staff. Objectives: Current research intended to evaluate the annual effective doses of radiology department's staff during bone scans and their health hazards due to radiation. Methods: The study was executed at Nuclear Medical Center, in October 2022 and annual effective dose of radiologists were measured implying the two techniques including <sup>99m</sup>Tc-MDP TLDs, carrying two dose quantities of Hp (10) and Hp (0.07) and GR-200A TLDs (LiF: Mg, Cu, P). Results: Effective dose of

operators was evaluated using  $^{99m}\text{Tc}$ -MDP TLDs, was found that the mean personal equivalent dosimetry of HP 10 was 0.43 (0.12-0.74) and HP 0.07 was 0.52 (0.11-0.76). Relative strength of residual signal for successive readouts of LiF: Mg, Cu, P chips made had mean GR-200A and Ref. 10 of  $0.54 \pm 0.23$  and  $3.10 \pm 1.12$ , respectively. Conclusion: The radiographers in all of the X-ray facilities were well aware of radiation safety and the staff's occupational dosages of HP(0.07) and HP (10) were within the recommended limits. The study recommended further raising staff awareness of radiation safety to ensure safety against radiogenic dangers to both operators and patients.

**Keywords**---dosimetry, effective radiation dose, occupational doses, x-rays.

## Introduction

In the past decade, the introduction of contemporary medicinal imaging technology and appliance of radioactive isotopes in nuclear medicine has led to a more precise disease diagnosis. Yet, the use of ionizing radiation, for instance X-rays or gamma rays, unavoidably carries a radiogenic risk. Thus, evaluation of radiation doses incurred by radiology staff is becoming a crucial topic. Radiation injuries to tissues and organs depend on numerous variables, including amount and kind of radiation as well as their susceptibilities to radiation. Even tiny doses of ionizing radiation can raise likelihood of long-term consequences such as cancer <sup>1-2</sup>. By lowering radiation dose given to patients in accordance with the medical use of radiation, radiologic technicians are trying to improve public health care <sup>3</sup>.

Around 40.0 (Millions) nuclear medicine (NM) procedures are conducted annually, with 65% of those procedures being related to oncology, and the need for radioisotopes is increasing at a pace of up to 5%. When using radiopharmaceuticals for diagnostic reasons, a radioactive dose is given to the patient, and radioactivity in the organ can subsequently be evaluated as either a 2D or a 3D image. The radionuclide that is frequently employed in medical imaging is  $^{99m}\text{Tc}$ , which is used in around 80% of all NM exams. A synthetic element called  $^{99m}\text{Tc}$  has almost ideal characteristics for NM imaging, acceptable energy, isomeric decay and half-life ( $t/2$ ) = 6 hours (140 keV) <sup>4</sup>. Scintigraphy is a radionuclide-based bone imaging, which is employed as a diagnostic procedure to examine bone diseases and malignant metastases across the body to find the spread of cancer and diagnose pathological conditions. It is a quick, fairly valued diagnostic test used to evaluate several pathologic disorders and is often available in many imaging facilities. Even though radiation is not evenly spread throughout the world, more diagnostic nuclear medicine exams are performed each year <sup>5-6</sup>.

According to the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR), 3.6 billion diagnostic radiographs were inspected by X-ray machines worldwide yearly, creating the International Radiological Survey indispensable for inspecting diagnostic radiology tools. The medical physicist in

medical imaging is accountable for preparing the records and report documents inside the institution. Among the most important reports are: quality control test reports, the inventory report, the calibration of area radiation survey, record of personnel dosimetry for radiation personnel at such a facility *etc* <sup>7</sup>.

The standard radioactivity dose is dependent upon the patient's weight and criteria like pregnancy and occasionally renal function are taken into consideration as limiting variables before the NM exam can start. More dosages are typically required for obese patients compared to normal-weight patients to achieve satisfactory image quality. To ensure image quality, accurate diagnosis, and to reduce signal-to-noise ratio and radiation scattering, the International Committee on Radiation Shielding advises keeping radioactive dose for imaging as low as feasible. Such advice is not clear when it comes to Positron Emission Tomography (PET), recommending the imaging dose be limited to 925 Mbq and determined according to tolerant weight to trounce scatter-related image quality issues (25 mCi) <sup>8</sup>. Therefore, this research was conducted at Rawalpindi, Islamabad, Pakistan, for the assessment of staff of the radiology department's annual effective doses during bone scans and their health hazards due to radiations.

## **Material and Methods**

### **Study period and location**

The study was conducted at Nuclear Medical Center, Rawalpindi Islamabad, Pakistan in October 2022.

### **Techniques for assessment of annual effective dose**

Thermoluminescent dosimeters (TLDs) were often employed for personnel monitoring in diagnostic radiology and nuclear medicine. Two dose quantities of Hp (10) and Hp (0.07) were calculated for staff members. For this purpose, 07 technologists were monitored for occupational exposure during 50 bone scan operations and their demographic characteristics were also recorded. At the NMC department, technologists were responsible for 99mTc elution and the imaging process. During all procedures, the technicians wore lead aprons and used personnel protective equipment. Based on patient weight, mean and range of 99mTc-MDP the effective dose was 570 (344-896) MBq. Two to three hours prior to scanning, eluted NaTcO<sub>4</sub> is combined with methylene diphosphonate MDP and administered intravenously. The subject was scanned with a gamma camera with a single head.

GR-200A TLDs (LiF: Mg, Cu, P) were employed to determine the dose. All TLDs were circular chips with a thickness of 0.8 mm and a diameter of 4.5 mm. The Fimel PCL3 TLD reader was employed to interpret TLD signals that were heat annealed at 240 °C for 10 mins, with subsequently rapid cooling in controlled oven. The Solid Dosimetric Detector technique prepared each sample of LiF: Mg, Cu, P used (SDDML, China). LiF: Mg, Ti (TLD-100). The manual reader, type RGD-3, with a GDB-52 photomultiplier tube (PMT) of Sb-K-Cs, a bi-alkaline cathode with a spectral response of 300-650 nm, and a ZB12 filter built in China

was thermoluminescence readout apparatus used in the current research. An air-circulating oven with a temperature that could be adjusted to within 1°C was utilized for annealing. A Bio-Rad FTS185 Fourier infrared spectrum equipment was used to measure the infrared spectrum.

### **Ethical approval**

Before beginning the data-gathering process, ethical approval and staff and patient consent were obtained.

### **Statistical analysis**

All the collected data was compiled in MS Excel sheets and were statistically analyzed using SPSS 20 software. The treatment groups were analyzed using a One-way ANOVA test including Tukey HSD.

### **Results**

The study was conducted at Nuclear Medical Center, Rawalpindi Islamabad, Pakistan in October 2022 and determined the annual effective dose of staff members and radiologists working on bone scan operations. Two techniques were employed for the detection of their effective doses including 99mTc-MDP TLDs and GR-200A TLDs. The demographic characteristics of the participants revealed that the staff members had a mean age of 32.65±7.87 years, a mean weight of 76.14±15.42 and they were all males. Their effective dose was evaluated after the operation of 50 bone scans performed by each staff member and they were administered with 570 MBq of 99mTc-MDP dose (Table 1). The effective dose of NMC staff members was evaluated using 99mTc-MDP TLDs and it was found that the mean personal equivalent dosimetry of HP 10 was 0.43 (0.12-0.74) and HP 0.07 was 0.52 (0.11-0.76) (Figure 1). The relative strength of the residual signal for successive readouts of LiF: Mg, Cu, and P chips made was displayed in Table 2. Following the 240°C readout, the residual signal (second readout) had been observed with the mean GR-200A and Ref. 10 of 0.54±0.23 and 3.10±1.12, respectively (Table 2).

Table 1  
Demographic characteristics of the NMC staff members

S. No	Variables	Range	Mean + SD
1	Age (years)	24-47	32.65±7.87
2	Weight (kg)	52-97	76.14±15.42
3	No. of bone scans (n)	50	---
4	99mTc-MDP dose	344-896	570.0

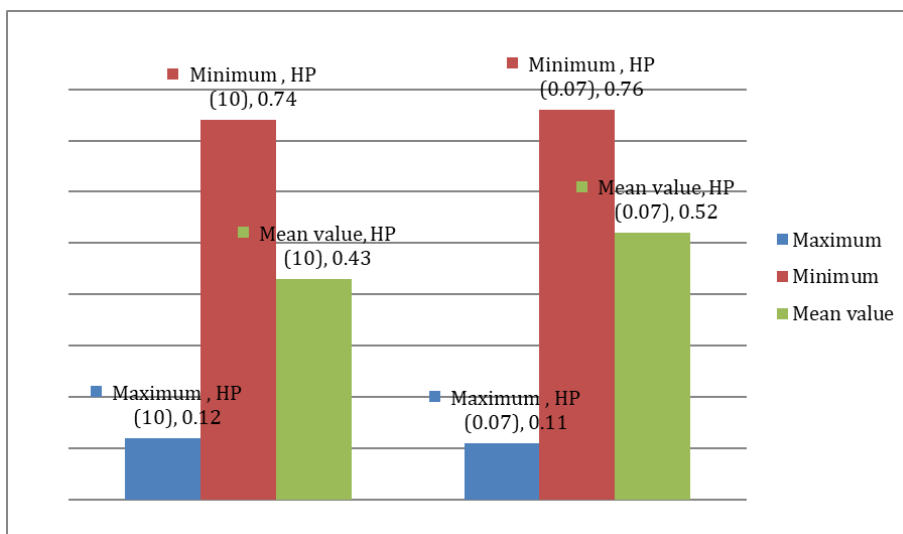


Figure 1. Demonstration of an effective dose of NMC staff members using TLDs

Table 2  
Integrated intensity of residual signals of GR-200A TLDs (LiF: Mg, Cu, P)

S. No	Variables	Minimum intensity	Maximum intensity	Mean intensity
1	GR-200A	0.27	0.87	0.54+0.23
2	Ref. 10	0.9	7.4	3.10+1.12

## Discussion

The most frequent imaging techniques used by NM departments are skeletal scintigraphy and bone scans. To assess the protective measures and anticipated radiation hazards, it is crucial to evaluate the patient's doses for the NMC staff. Our findings were comparable to the studies revealing that given  $^{99m}\text{Tc}$ -MDP activity during bone imaging (MBq) varied between 740.0 and 1110.0, with scanning often taking place two to five hours following intravenous radiopharmaceutical administration, and the amount of radioactivity administered, the radioactive element, and length of patient contact time all affect the usual dose during skeletal scanning <sup>4, 9</sup>. The mean yearly occupational exposures for GxTs, CTTs and Rads groups in this investigation were between 0.27 and 0.51 mSv, which is consistent with our findings <sup>1</sup>. Comparable outcomes were received from Saudi Arabia staff members and technicians <sup>10</sup>. It's important to note that bone scans expose personnel to higher radiation dosages. These average outcomes were 4.5 times better than the renal scan dosage estimates. Also, because of the bigger administered activities involved in bone scans, the cancer risk likelihood per procedure is highest <sup>11</sup>. Like our findings, annual personal dose equivalent (Hp (10) and Hp (0.07) mSv) had mean and standard deviations of 7.6 (3.2-9.1) and 30 (17.2-44.0), respectively. The fact that the injected patient spent a lot of time with the technologist both before and throughout the scanning operation can be blamed for the hand dosages <sup>9, 12-13</sup>. Our findings were also supported by a research illuminating that initial 29 times

advanced sensitivity of GR-200A was upgraded to 65 times the sensitivity of TLD-100. At 240°C reading, the residual signal was reduced from its initial value of roughly 2.5 to less than 1%. The signal-to-noise ratio rises while the detection threshold fell. Low dosage measurements had significantly less uncertainty <sup>14</sup>.

A study found that an active dose (152.9 mCi) of a bone scan significantly decreased WBCs by 3.8% relative to age and BMI at P-values of 0.00 and 0.05, respectively, but only slightly (P-value = 0.32) decreased RBCs by 3.6% relative to normal <sup>8</sup>. Similar results were obtained from another study, showing that WBCs count of patients was abridged by 3.8% (221.8) on average post 03 hours of 99mTc inoculation. This decline was significant at (P= 0.00, t = 17.6), indicating that either the radiation destroyed the WBC or that it could have changed their morphology, rendering detectors unable to distinguish and depict them, or would cause suppression of blood-forming organs <sup>15</sup>.

According to a report, the operator needs to be conversant with the instructions and paperwork pertaining to the radiation protection program at each institution. The operator console's shielding measures were enough to prevent unneeded radiation exposure. Also, each institution has access to personal protective equipment such as thyroid shields and lead glass. The lead apron holder was the primary requirement of each radiology facility, but it wasn't always used. It's vital to note that the majority of the facilities that were inspected had protective barriers like gonad shields and leaded screens. According to the SFDA report, 40.7% of the inspected facilities do not keep a record of the personal dosimeter reading at their facilities, and about 21.9% of those facilities did not have any personal radiation dosimeters, such as thermoluminescent dosimeters (TLD) or optically stimulated luminescence (OSL) devices <sup>7, 16, 17</sup>. Such neglecting circumstances increase the annual effective doses of the operators and staff members, rendering them to radiation exposure and increasing the probabilities of cancers and fatalities <sup>18</sup>.

## **Conclusion**

This study assessed the diagnostic radiology staff and technicians' effective doses at Nuclear Medicine Centers. The radiographers in all of the X-ray facilities that were under investigation showed that they had a solid grasp of the principles governing radiation safety and the security of radiation sources. The staff's occupational dosages of HP(0.07) and HP(10) were discovered to be within the advised limits. LiF: Mg, Cu, P was found satisfactory TL material for personal dosimetry due to its exceptional combination of high sensitivity and strong tissue-equivalence. The study recommended further raising staff awareness of radiation safety. Staff exposure will be kept within safe limits with the support of staff training and careful adherence to the protection principles. To ensure safety against radiogenic dangers to both operators and patients, they must follow radiological protective practices.

## **Conflict of interest**

None.

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