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Original Article

Analysis of dose monitoring for external exposure to radiology in hospital workers from 2010 to 2018

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Abstract: Objective: To investigate the individual level of radiation exposure in hospital workers from 2010 to 2018. Methods: Oral radiology workers in our hospital including medical imaging technicians and radiation therapists from 2010 to 2018 were selected as the subjects of investigation. The oral radiological workers were monitored quarterly according to the level of external exposure via individual dose monitoring standards. The monitoring data were aggregated, analyzed and evaluated. Results: A total of 531 hospital radiology workers were monitored from 2010 to 2018. The rate of effective monitoring per year for medical imaging technicians and radiation therapists was 97.35% and 97.47%, respectively. The average collective effective dose was 8.511 mSv, and annual effective dose per capita was 0.148 mSv. The highest collective effective dose was in 2017, while the highest annual effective dose per capita was in 2010. The annual effective dose per capita for medical imaging technicians was lower than that for radiation therapists. The abnormal rate of personal doses of radiation therapists was higher than that for medical imaging technicians. The collective effective dose changes in the two types of radiation workers were monitored from 2010 to 2018, showing an increased trend. The fluctuations of annual effective dosing per capita monitored from 2010 to 2018 in radiation therapists was more significant than that in medical imaging technicians. Conclusions: Oral radiation workers monitored were all far below the dose limit of 20 mSv, which indicated that the working environment of oral radiation workers in our hospital was safe with good radiation condition and protection.

Keywords: External exposure, oral radiation worker, individual dose, monitor

Introduction

With the application and development of radiological diagnosis and therapy technology, the number of occupational workers who engaged in radiological diagnostics in hospitals has been increased in recent years [1, 2]. Occupational radiation dosing has become the focus of radiological protection [3, 4]. For oral radiological workers, the capturing of dental film involved in oral treatment and radioactive particle implantation has been applied for many years in the treatment of oral and maxillofacial tumors [5]. For the protection of oral radiation workers, personal dose monitoring is an effective technical means to evaluate the external exposure of the dose received by radiation workers [6, 7]. It was reported that personal dose monitoring for external exposure was an important component for the health management of radiation workers [8, 9]. In clinical practices, personal dose monitoring of external exposure was defined as the measurement of personal exposure using a dosimeters worn by radiation workers, and the interpretation of the measurement results [10]. It was reported that Hp (10) was suitable for the monitoring of organs or tissues at a depth of 10 mm below the body surface, and was used for effective dose evaluation under specific conditions [11]. In a relatively uniform radiation field, when the radiation is mainly from the front, the dosimeter should be worn generally on the left chest of radiation workers. The accurate monitoring of the dose exposure in radiation workers can help to evaluate the safety of radiation workplaces and provide a dose basis for the health status of radiation workers and the diagnosis and treatment of radiation diseases [12, 13].

In order to understand the personal dose conditions of oral radiation workers and the effect of radiation protected from ionizing radiation in the work environment, the retrospective analysis of personal dose monitoring results of external exposure for oral radiologic worker in a hospital from 2010 to 2018 were conducted. The results of this study also provide a reference for correct evaluation of the radiation dose for radiation workers and the development of management measures.

Material and methods

Subjects

All the oral radiological workers in our hospital were selected for personal dose monitoring from 2010 to 2018. Their occupations mainly included medical imaging technician and radiation therapists. Oral radiological workers who correctly wore the dosimeters were included in this survey. The oral radiological workers included in this survey had complete data of monitoring doses. All oral radiological workers were aware of and wore personal dose monitoring detectors. They were included in this retrospective study and were regularly informed of the results of personal dose. New employees and employees who left during the study were not included in this survey. The oral radiological workers who were unwilling to participate in this survey were excluded. All selected participants signed an informed consent, and this study was approved by the ethics committee of our hospital.

Methods of monitoring

The dual monitoring method of thermoluminescence dosing was used for personal dose monitoring. The component of the thermoluminescence detector was GR-200A type LiF (Mg, Cu, P) wafer materials with a 4.5 mm×0.8 mm diameter. The dose box was a TLD469 type. The thermoluminescence dosimeter worn by each worker was identified by a unique barcode. The measuring and reading instrument was a RGD-3B thermoluminescence dosimeter. Personal dosimeters were required to be worn on the left side of the chest of the radiological workers. Those with protective clothing wore the dosimeters in protective clothing. There were 4 periods of monitoring throughout the year, and each monitoring period was 90 days. After dosimeters were worn for one period, specially-assigned persons collected the dosimeters and sent them to a professional institution for testing and replaced them with a new dosimeter. The followings were considered as abnormal dose levels: The average annual effective dose of the individual for 5 years was more than 20 mSv or the effective dose of the individual in one year was more than 50 mSv.

Quality control

The thermoluminescence dose measurement system was regularly calibrated by the institute of technology. Various indicators such as scale, dispersion, linearity, uncertainty, detective threshold, and energy response meet the requirements of personal dose monitoring. The dose detectors were obtained from the same batch production, in order to ensure consistency of the detectors. The strict operative procedures were established. Specially trained persons were responsible for the annealing and reading of the dose detector. For those who exceed the dose limit during the measurement process, it was required to examine the abnormal situations in a timely manner and correct abnormal data to ensure the authenticity of the results. A dose survey for abnormal exposure conditions was conducted when the dose was more than 1.25 mSv in one period of monitoring.

Statistical analysis

All the data in this study were performed by SPSS 17.0 software. The measurement data were expressed in form of median. The comparison between two groups was conducted by Kruskal-Wallis Test. $P < 0.05$ indicated that there were significantly statistical differences.

Results

Basic information of monitoring

From 2010 to 2018, the total number of people monitored was 531, and the number of people effectively monitored was 517. The total rate of effective monitoring per year was 97.36%. Among them, the rate of effective monitoring per year for medical imaging technician was 97.35% and the rate of effective monitoring per year for radiation therapists was 97.47%, as seen in **Table 1**.

Table 1. Effective monitoring results for oral radiologic worker in a hospital from 2010 to 2018

Occupation	Number of actual monitoring	Number of effective monitoring	Rate of effective monitoring per year (%)
Medical imaging technician	461	452	98.05
Radiation therapist	85	79	92.94
χ^2 value			7.005
P value			0.008

Table 2. Personal dose monitoring results of external exposure for oral radiological workers in a hospital from 2010 to 2018

Years	Number of monitoring (Cases)	Collective dose (mSv)	Annual dose per capita (mSv)
2010	35	6.582	0.188
2011	40	5.763	0.144
2012	49	7.769	0.159
2013	50	7.367	0.147
2014	64	7.942	0.124
2015	61	7.117	0.133
2016	71	9.527	0.134
2017	80	12.624	0.158
2018	81	11.916	0.147

Table 3. Personal dose monitoring results of external exposure for different oral radiological workers in a hospital from 2010 to 2018

Occupation	Number of monitoring (Cases)	Collective dose (mSv)	Annual dose per capita (mSv)
Medical imaging technician	452	62.928	0.139
Radiation therapists	79	14.679	0.185

Personal dose monitoring results in different years

As shown in **Table 2**, there were 531 oral radiological workers for personal dose monitoring in the nine years. The average collective dose was 8.511 mSv, and annual dose per capita was 0.148 mSv. The highest collective dose was in 2017, while the highest annual dose per capita was in 2010. The lowest collective dose was in 2011, while the lowest annual dose per capita was in 2014.

Personal dose monitoring results for different oral radiologic workers

As seen in **Table 3**, the collective effective dose for Medical imaging technicians was 62.928 mSv, which was obviously higher than that for radiation therapists (14.679 mSv). However, the annual effective dose per capita for Medical imaging technicians was 0.139 mSv, which was lower than that for radiation therapists (0.185 mSv).

Abnormal rate of personal dosing for different occupations

There were total 531 cases of personal dose monitoring from 2010 to 2018. Among them, there were 4 cases with abnormal personal doses. In term of occupation, the abnormal rate of personal dosing for medical imaging technicians was 0.22% while the abnormal rate of personal dosing for radiation therapists was 2.53%, as seen in **Figure 1**.

Trend of collective effective dosing for different oral radiologic workers

There was an increased trend for collective effective dosing in the two kinds of oral radiological workers. The highest collective effective dose for medical imaging technicians and radiation therapists was in 2017 and 2018, respectively. The lowest collective effective dosing for medical imaging technician and radiation therapists was in 2011, as shown in **Figure 2**.

Trend of annual effective dosing per capita for different oral radiologic workers

The fluctuation of annual effective dosing per capita in radiation therapists was more significant than that in medical imaging technicians. The annual effective dose per capita for medical imaging technicians and radiation therapists was in 2010 and 2012, respectively. The lowest collective effective dose for medical

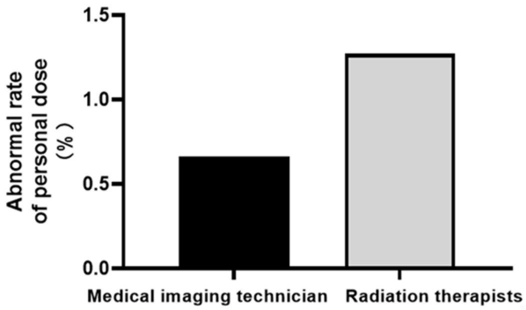

Figure 1. Abnormal rate of personal dosing for different oral radiological workers in our hospital from 2010 to 2018.

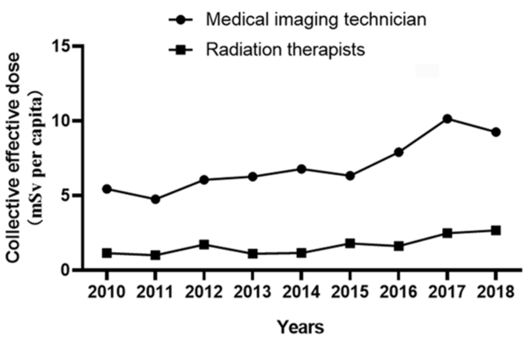

Figure 2. Trend of collective effective dosing for different oral radiological workers in our hospital from 2010 to 2018.

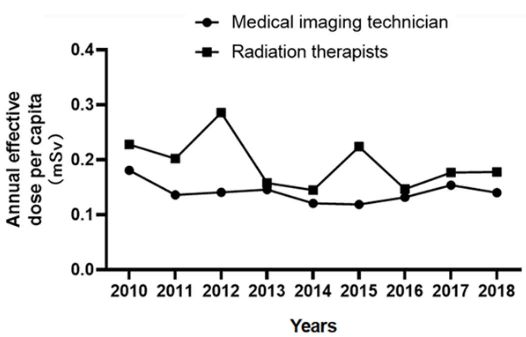

Figure 3. Trend of annual dose per capita for different oral radiological workers in our hospital from 2010 to 2018.

imaging technicians and radiation therapists was in 2015 and 2014, as shown in **Figure 3**.

Discussion

Personal dose monitoring played an important role in the occupational health management system of radiation workers. It is characterized by continuous monitoring [14, 15]. It was widely used as a measurement tool which ensured the safety and health of radiation workers. It was reported that this method can not only be applied for assessing the trends of exposure dose and evaluation or improvement of radiation protection measures or operating procedures, but also be considered as important data for epidemiological studies on evaluating the effects of low-dose ionizing radiation on human health and diagnosis of occupational diseases [16, 17]. Some studies also reported that personal dose monitoring can reflect the recent radiation exposure levels of radiation workers, in a timely manner detect occupational hazards, and ensure the health of radiation workers. In this study, it was shown that the total rate of effective monitoring per year was 97.36%, which was similar with results reported by other studies [18, 19]. A total of 531 cases were monitored, among which 14 cases lacked the dose of a single quarter, all of which were the loss of personal dose monitoring detectors due to personal reason. The missing dose of a quarter did not have much impact on the dose of the whole year, and in fact could not be regarded as invalid monitoring. It also indicated that the development of personal dose monitoring of external exposure for oral radiologic worker in our hospital from 2010 to 2018 was satisfactory.

In this study, medical imaging technicians and radiation therapist were the main subjects for personal dose monitoring. The results showed that there were obvious differences for collective effective dose and annual effective dose per capita between two kinds of oral radiation workers. The greater amount of effective dosage collectively was in medical imaging technicians due to the large number of medical imaging technicians. However, the annual effective dose per capita in medical imaging technicians was lower than that in radiation therapists. This indicated that the radiation protection measures in radiological imaging were relatively complete, and the workers had good protection awareness. These results were consistent with results reported by Bly et al [20]. Moreover, it was reported that radiation therapists were completely exposed to X-rays during the process of treatment, and they were not able to conduct the compartment operations or remote operations [21]. At present, the proportion of oral radiation workers engaged in these two kinds of occupations was relatively high, and it will still be increasing in the future. Therefore, it is necessary to continue to carry out in-depth personal dose monitoring of these two types of radiation workers, strengthen professional skills and radiation protection training, which will further improve their protection, and reduce radiation doses as much as possible.

In term of abnormal personal dosage, this study showed that there were 3 cases with abnormal personal dose amounts among the 531 cases with personal dose monitoring. In this study, the abnormal personal dosage is defined as exceeding the dose limit for individual hospital radiation workers, less than 2 mSv per year and less than 0.5 mSv per quarter. The abnormal rate of personal dosage was similar with results reported by previous studies [22]. The reasons were as follows [23]: dosimeters had been placed in the workplace, dosimeters were not worn correctly, the same dosimeter was worn by many radiation workers and workload significantly increased. This study also suggested that relevant training was very important for radiation workers. It is not only required to carry out good training for radiation protection knowledge and relevant laws and regulations, but also to conduct a targeted training regime of professional practice techniques and operations. In order to reduce the exposure dose to radiation workers as much as possible, the following interventions were recommended [18, 24]: further strengthen the training of radiation protection knowledge, enhance the protection awareness of radiation workers, and allow radiation workers to take the initiative to protect themselves from radiation exposure. Internal supervision of institutions and medical organization withing themselves should enhance their own supervision and investigate the causes of excessive radiation dosing. The radiation protection facilities need to be improved to reduce the radiation level of radiation workers. It is necessary to establish a rotation system for positions with heavy radiation workloads and reduce the time of exposure to radiation and protect the health of radiation workers.

In summary, the monitoring of radiation exposure has changed time goes by. Compared with that in radiation therapists, the annual effective dose per capita in medical imaging technician was lower. The monitoring dose of oral radiation workers in a hospital was far below the dose limit 20 mSv, which indicated that the working environment of radiation workers was safe, stable, and with good radiation protection conditions. However, there were some limitations in this study; as this was a single-center survey. It had no information on risk factors affecting personal dose of external radiation exposure. It was not a comparative study. In the future, in-depth study should be conducted to protect the health of radiation workers.

Disclosure of conflict of interest

None.

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