The Assessment as Bone Mineral Density of Bone Damage in Radiology Workers Occupationally Exposed to Ionizing Radiation

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ABSTRACT

We examined the effects of occupational ionizing radiation exposure in radiology workers on bone mineral density and serum alkaline phosphates (ALP) levels. 49 subjects, aged between 21-48 years (33.86 years), working in the department of radiology were enrolled to this study. 26 subjects were female and 23 were male. Control group consisted of 40 healthy subjects aged between 22-49 years (mean 33.83) who had never been exposed to radiation; 21 of these were female and 19 male. Venous blood samples were obtained from the radiology workers and control group and serum alkaline phosphatase levels analysis of samples were performed. The bone mineral density (BMD) was assessed in the spine and the hip with a dual-energy x-ray absorptiometry (DEXA) instrument. T-scores of radiology workers was lower than control group significantly (P < 0.01). Serum ALP levels of radiology workers was lower than control group significantly (P < 0.01). T-scores and serum ALP levels of private sector workers were lower than state hospital workers but there was no significantly difference among them (P > 0.05). T-scores of the men at the control group were higher than the women's however the case was just the opposite for the work group. In radiology workers exposed to long-term low-dose ionizing radiation has negative effect on bone mineral density and serum ALP levels.

Key words: *Radiation, bone mineral density, serum ALP.*

Mesleki İyonize Radyasyona Maruz Kalan Radyoloji Çalışanlarında Kemik Hasarının Kemik Mineral Yoğunluğu Olarak Değerlendirilmesi

ÖZET

Biz radyoloji çalışanlarında mesleki iyonize radyasyon maruziyetinin kemik mineral yoğunluğu ve serum alkalin fosfotaz (ALP) seviyeleri üzerine etkilerini inceledik. Radyoloji departmanında çalışan, yaşları 21-48 (33.86) arasında değişen 26'sı kadın ve 23'ü erkek toplam 49 radyoloji çalışanı bu çalışma kapsamına alındı. Kontrol grubu, herhangi bir şekilde radyasyona maruz kalmamış sağlıklı, yaşları 22-49 (33.83) arasında değişen 21'i kadın ve 19'u erkek 40 kişiden oluşturuldu. Radyoloji çalışanı ve kontrol grubundaki kişilerin her birinden alınan venöz kan örneklerinden serum alkalin fosfotaz analizleri yapıldı. Omur ve kalça BMD'leri dual enerji x-ray absorptiometry (DEXA) cihazıyla ölçüldü. Radyoloji çalışanlarının T-skorları ve Serum ALP seviyeleri kontrol gruplarından anlamlı olarak düşük bulundu (p<0.01). Özel sektör çalışanlarının T-skorları ve serum ALP seviyeleri devlet hastanesi çalışanlarından düşük bulundu fakat aralarındaki fark anlamlı değildi (P > 0.05). Erkeklerin T-skorları kontrol gruplarında kadınlardan yüksek olmasına rağmen çalışma grubunda bu durumun tam tersi bulundu. Radyoloji çalışanlarında uzun dönem düşük doz iyonize radyasyon maruziyeti kemik mineral yoğunluğu ve serum ALP seviyeleri üzerinde olumsuz etkilidir.

Anahtar kelimeler: *İyonize radyasyon, kemik mineral yoğunluğu, serum ALP*

INTRODUCTION

All cells can be damaged by ionizing radiation, but actively dividing cells are more radiosensitive. Bone marrow stem cells are one of the most radiosensitive cells in the human body (1-3). Bone atrophy and bone fractures increase in patients after exposure to radiation (4,5).

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Spontaneous hip fracture incidence is higher in pelvic cancer patients after therapeutic irradiation (4,6). The bone loss effects of high levels of radiation exposure are fairly well known, but the effects of low levels of radiation are more difficult to determine because the deterministic effects do not occur at these levels. Long-term exposure to low levels of radiation may cause bone damage. Even if radiation is in low doses, long-term exposure to radiation decreases bone mineral density. Because of continuing irradiation, organism cannot repair damages on body until next irradiation and damages accumulate (7). The aim of this study is finding out the negative effects of exposure to low dose ionize radiation at bone mineral density and serum alkaline phosphates levels of radiology workers.

MATERIAL AND METHODS

The population studied comprised 89 volunteer bone mineral density and serum ALP: 49 of them had been occupationally exposed to ionizing radiation and 40 were unexposed control subjects. Each person completed a standardized questionnaire which included items concerning personal data (age and health status) and occupational exposure to ionizing radiation at the time of the study. The questionnaire also included items concerning non-occupational exposure to potential osteoporosis hazards, such as smoking, drug consumption, diseases and radiodiagnostic examinations. Technicians use lead wear and barrier while working as a protection method. The exposed group consisted of 26 female and 23 male subjects aged 21– 48 years (mean age 33.86 years) working in the radiology units of hospitals. 49 of them were radiological technicians. In the working group 34 technicians were working at state hospitals and 15 technicians were working at private hospitals. During their work they all wore individual TLD dosimeters (Thermo luminescence Dosimeter). The range of dosimeter readings for the exposed group during the year prior to the study was 1–6.6 mSv. Fifteen exposed subjects were smokers and 34 were nonsmokers. In the year prior to the beginning of the present study exposed subjects had not been subjected to diagnostic X-ray examinations. Control subjects were healthy employees (21 female and 19 male), chosen from the same hospital without occupational exposure to radiation. Twenty-nine of them were non-smokers and 11 of them were smokers. The mean age of the control group was 33.83 (range 22–49 years). None of them had ever had any contact with sources of ionizing radiation or been occupationally exposed to known genotoxic agents. None had received any therapeutic irradiation. The necessary information was given to the participants and they were informed of the harmful effects of minimum radiation absorption to their health and they gave their consent to join this study. Bone mineral density and serum alkaline phosphates values were used in order to collect data. We measured bone mineral density (BMD) in the lumbar spine and hip (neck and trochanter), using dual energy X-ray absorptiometry (DXA, Hologic QDR 4500), which is commonly used to evaluate BMD (8). Lumbar spine and hip measurements are general measurement areas to diagnose osteopenia and osteoporosis. For the measurement of serum ALP, participants fasting venous blood samples were taken in morning hours (07:00-09:00 a.m) and also these samples were separated into serums. Then, these samples were frozen at -20 C until the measurements. The measurements of serum ALP were done by means of Abbott Architect Plus-C 16000 device with photometry kinetic method.

Statistical Validation

While analysing results, we used 'SPSS 15.0' package program for statistical analysis. In order to compare of qualifying datas and normal parameters in groups Oneway Anova Test and in Post Hoc analysis LSD test and in two group comparisons independent-samples t-test were used. Datas were stated as average, ± standart deviation value. $P < 0.01$ was accepted as statiscally meaningful.

RESULTS

Our study did not find any significant associations between smoking, nutrition habits, exercises, illness, drug using and BMD ($P > 0.05$). According to DEXA results, the work group compared to control group regarding gender, age and as part of their daily work (at state and at private sector). In our study, we found out that T-scores of radiology workers were significantly lower than the control group ($P < 0.01$). Depending on gender, T-scores of radiology workers were significantly lower for both women and men than the control group ($P < 0.01$). It was also found out that T-scores of the men at the control group were higher than the women's however the case was just the opposite for the work group (table 2).

***Table 1**. Characters the groups of people*

	Radiology Workers	Control Group
Female/Male	26/23	21/19
Age	33.86±8.11	33.83±6.58
Min-Max.	21-48	22-49
Exposure (years)	10.42±5.52	11.21±5.14
Exposure (in last one year)	4.8 mSv	
State hospital (n)	34	
Private Hospital (n)	15	
Smoke	49 (15)	40 (11)

***Table 2**. DEXA results of group*

	Control Group	Radiology Workers	p Value
BMD (T-Skor)	0.64±0.68	-1.03±0.77*	0.000
Female. n	21	26	
BMD (T-Skor)	0.44±0.46	-0.76±0.79*	0.000
Male. n	19	23	
BMD (T-Skor)	0.86±0.81	-1.33± 0.63*	0.000

(*) p<0.01 According to control group.

In our study, the work groups were compared as part of their daily work at state hospitals and at private sector hospitals. Average age was 36,50±5,42 at state hospitals and it was 27,87±4,93 at private sector hospitals. In addition, radiology working, work length 13,44±3,13 years at state hospitals and it was 3,60±3,11 years at private sector hospitals. T-scores of radiology workers were significantly lower for both state and private sector hospitals than the control group (P < 0.01). In working group comparisons among themselves, T-scores of private sector workers were lower than state hospital workers but there was no statistically significant difference among them (P > 0.05) (table 3). Serum ALP levels of working group were lower than the control group significantly (P < 0.01) (table 4).

DISCUSSION

Our results show that there is a relationship between exposures to low dose ionizing radiation and low bone mineral density. The relationship between exposures to low dose ionizing radiation and low bone mineral density is strong. This decrease changes depending on the time and level of radiation exposure of radiology workers (9). Animal experiments have shown that bone mineral density at exposed to radiation is lower and osteoporosis can occur (10,11). In addition, heavy ionizing radiation in lumbar spines of mice's which are exposed to radiation caused bone mineral density decrease one month later (12). In these studies, one dose irradiation with heavy ionizing radiation and short time effects were also determined. In our study, we examined that the effects of the long-term low dose radiation on bone mineral density of radiology workers. These are long-term effects, which do not show in the exposed population until many years after the exposure. Radiation workers are predicted to have a greater percentage risk of developing detrimental effects over the general public because of their generally greater exposure. Even if radiation is in low doses, long-term exposure to radiation decreases bone mineral density. Because of continuing irradiation, organism cannot repair damages on body until next irradiation and damages accumulate (7). We found a decreased of bone mineral density in the workers than healthy controls.

Regarding published reports ionizing radiation has harmful biological effects on living organisms and this effects increase depending on radiation dose and exposure time to radiation (9,13-16). In addition, our study shows that depending on radiation exposure, bone mineral density decreases significantly of all radiology workers compared to control group. Radiation affects at private sector workers more than state sector workers. Private sector radiology workers are younger than state sector radiology workers and there is ten years work length difference between them on average however T-scores

***Table 3**. Analysing in accordiance to olderness, working periode of time and working in state and private sector*

	Control	State Radiology Workers	Private Radiology Workers	p Value
Age (at average)	33.83±6.58	36.50±5.42	27.87±4.93	
Exposure (years)	11.21±3.14	13.44±3.13	3.60±3.11	
BMD (T-Skor)	0.64±0.68	-0.98±0.81*	-1.15±0.70*	0.000

(*) p<0.05 According to control group.

Table 4. *Serum ALP levels of groups*

	Control	State Radiology Workers	Private Radiology Workers	p Value
ALP (U/L)	97.88±37.66	85.26±20.45*	78.68±15.11*	0.000

(*) p<0.05 According to control group.

of private sector workers were lower. After ten years it is possible that bone mineral density of private sector workers can be affected seriously. This may happen because they have more working hours, more patients and less holiday time than state workers.

Depending on gender, T-scores of radiology workers were significantly lower for both women and men than the control group. But in our study bone mineral density of the men decreases more and radiation is more effective on them. Amin et al reported that serum estrodiol levels is more valid and significant than testosterone levels for men who has in order to determine bone mineral density (17). In another study, it was showed that estrogen and testosterone both are important in bone production continuity but estrogen is major sex steroid in regulation of bone resorption (18) As it is seen in studies, estrogen is determining factor for bone mineral density of both men and women. For this reason, decreasing of bone mineral density of men can depending on damage of sex hormones.

It has seen that bone mineral density decreases after therapeutic irradiation. It is considered that missing of bone mass occur because of the bone osteoblastic formation and bone vasculature damages (19-21). Firstly, we studied bone mineral density missing on radiology workers. There is no study about the effects of radiation on bone mineral density of radiology workers. Ionizing radiation inhibits osteoblast proliferation, increases sensitivity to agents that induce apoptosis and reduces collagen production (22-24). A progressive decline in osteoblast number occurs in the first month after irradiation (25,26). ALP is synthesized by osteoblasts and ALP is a very sensible test to show osteoblastic activity. In our study, serum ALP levels are low and it supports this information. After irradiation osteoclastic activity increases (27) and osteoclast activity after irradiation could contribute to the reduction in bone volume and density in concert with the presumed eventual reduction in osteoblast function. Osteoclasts are responsible cells for bone resorption. Osteoclasts resorbe bone mineral matrix and hydrolyze organic matrix by enzymes.

It was found out that radiation has decreasing effect on bone mineral density of radiology workers. There was a suggested dose-effect relation between ionizing radiation dose and bone mineral density. Furthermore, there was a suggested dose response relation between ionizing radiation dose and osteoporosis and these decreases depending on gender and working place category as state and private sector. Although the present study population is small, the findings indicate that ionizing radiation may cause bone demineralization at a lower dose of ionizing radiation. It is necessary for radiology workers to have hematologic tests at least once a year and also DEXA measurement should be done periodicaly.

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