The Effects of Radiation on Bone Mineral Density of Radiology Workers Depending on The Device They Use

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ABSTRACT

Aim: *The aim of this study is to evaluate the effects of occupational radiation exposure according to the device radiology workers use regarding bone mineral density and and serum alkaline phosphatase (ALP) levels*

Method: *In our study, private and state hospitals at Kütahya centrum, low dose radiation occupational exposure in 49 radiology workers (conventional roentgen, tomography and mri) were compared with 40 non-exposed workers of the same hospitals in terms of bone mineral density and serum alkaline phosphatase levels. The bone mineral density (BMD) was assessed in the spine and the hip with a dual-energy x-ray absorptiometry (DEXA) instrument. Age and sex matched control groups were evaluated by T scores, commonly were used to assess osteoporosis.*

Result: *According to the device they use, T-scores of radiology workers (in all groups) were lower than the control group meaningfully ($p<0.01$). Moreover, T-scores of mri workers was lower than conventional roentgen workers meaningfully ($p<0.01$). Respectively; MRI <Tomography< Conventional roentgen < Control. Regarding the device they use, serum ALP levels of roentgen and tomography workers were lower than control group meaningfully ($p<0.05$).*

Conclusion: *it was determined that exposures of ionizing and non-ionazing radiation has decreasing effect on bone mineral density and serum ALP levels of radiology workers.*

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

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Radyoloji Çalışanlarının Kullandığı Cihaza Bağlı Kemik mineral yoğunluğu Üzerine Radyasyonun Etkileri

Amaç: *Bu çalışmanın amacı radyoloji çalışanlarının kullandığı cihaza göre mesleki radyasyon maruziyetinin kemik mineral yoğunluğu ve serum ALP seviyelerine etkilerini değerlendirmektir.*
Metod: *Çalışmamızda Kütahya merkezdeki özel ve devlet hastanelerinde mesleki düşük doz radyasyon maruziyetindeki 49 radyoloji çalışanı (konvansiyonel röntgen, tomografi ve MRG) radyasyona maruz kalmayan aynı hastanelerin 40 çalışanı ile kemik mineral yoğunluğu ve serum ALP seviyeleri bakımından karşılaştırıldı. Omur ve kalça BMD'leri dual enerji x-ray absorptiometry (DEXA) cihazıyla ölçüldü. Kontrol grupları yaş ve cinsiyet bakımından eşleştirildi. T-skor değerleri kullanıldı, osteoporozun belirlenmesinde yaygın olarak kullanılır.*
Bulgular: *Radyoloji çalışanlarının kullandığı cihaza göre T-skorları (bütün gruplarda) kontrol gruplarından anlamlı olarak düşük bulundu (p<0.01). Kendi aralarında, MRG çalışanlarının T-skorları konvansiyonel röntgen çalışanlarından anlamlı düşük bulundu. Sırasıyla; (MRG<tomografi<konvansiyonel röntgen<kontrol). Kullandığı cihaza göre, serum ALP seviyeleri röntgen ve tomografi çalışanlarının kontrol grubundan anlamlı düşük bulundu (p<0.05).*
Sonuç: *İyonize ve noniyonize radyasyon maruziyeti radyoloji çalışanlarının kemik mineral yoğunluğu ve serum ALP seviyeleri üzerine düşürücü etkilidir.*

Anahtar kelimeler: *Radyasyon, kemik mineral dansitesi, serum ALP*

INTRODUCTION

Harmful effects of radiation on human health are known for a long time. These are burn effects of radiation, decrease of human lifespan, cancer, congenital disorders and illnesses caused by radiation. Sometimes, it is possible to see sudden deaths because of high dose of radiation exposure. 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 (1,2). Nowadays, osteoporosis is an important health problem both for men and women. It is shown that radiation has harmfull effects on bone mineral density. Bone atrophy and bone fractures increase in patients after exposure to radiation (3,4). Spontaneous hip fracture incidence is higher in pelvic cancer patients after therapeutic irradiation (3,5). The aim of this study is finding out the changes at bone mineral density and serum alkaline phosphatase levels of radiology workers according to the device they use.

MATERIALS AND METHODS

In our study, 49 radiology workers (technicians) of total 55 ,which were volunteer for the study, exposed to ionizing and nonionizing radiation due to their profession in Kütahya's state and private hospitals are chosen as working group. Technicians use lead wear and barrier while working as a protection method. The quantity of radiation, radiology workers were exposed to in last one year, is measured by TAEK (Turkey Atomic Energy Instute) by means of using individual TLD (Thermoluminescence Dosimetry). It was measured 4,8 mSv at average. Table 1 shows characteristics of subjects. The control group have been working in the same hospital's radiology departments with working group, but control group has not exposed to radiation. Additionally, these people haven't been exposed to any diagnostic and therapeutic irradiation in the last one year. The necessary information was given to the participants and they were informed of the harmful effects of minimum radiation absorbtion to their health and they gave their consent to join this study. Bone mineral density and serum alkaline phosphatase values were used in order to collect data. Ionizing radiation levels were measured by geiger devices in conventional roentgen and tomography rooms and places where the control group works. Electromagnetic radiation level could not be measured in MRI rooms and places where the control group works, since we could not find necessary equipment. Our aim in these measurements was comparing radiation levels between working places of the working and the control groups. In this study, lumbar spine and hip (neck and trochanter) DEXA measurements was made and we used the lowest T score level. For the measurement of serum ALP, participants fasting venose blood samples were taken in morning hours (07:00-09:00 a.m) and also these samples were seperated 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.

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

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

	Radiology	Control
Female/Male	26/23	21/19
n	49	40
Age	33.86±8.11	33.83±6.58
Min-Max.	21-48	22-49
Work length (year)	10.42±5.52	11.21±5.14
total exposure	4.8 mSv	
Roentgen workers (n)	34	
Tomography workers (n)	9	
MRI workers (n)	6	
Smoke	49 (15)	40 (11)

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

After the first measurements of radiation, there was no radiation both in control rooms and radiation working rooms. It was found out that radiation stays 22 seconds at the room after irradiation and technicians leave from lead barriers at the first 3 seconds. Conventional roentgen workers, while working, are exposed to radiation between the doses of 0,0031 mSv and 0,15 mSv. In tomography, seconder radiation is between 0,57 mSv and 1,3 mSv after every irradiation (Table 2). According to DEXA results, the working group was compared to control group regarding the device they use. In our study it was found out that T-scores of radiology workers, in all groups, were lower than control group meaningfully (p<0.01). Moreover, T-scores of MRI workers were lower than conventional roentgen workers meaningfully (p<0.01). T-scores of tomography workers were lower than conventional roentgen workers and it was higher than MRI workers but there was no statistically significant difference among the groups (P>0.05). MRI <Tomography< Conventional roentgen < Control (Table 3). Depending on sex, if we compare according to the device they use, T-scores of radiology workers (all groups) were meaningfuly lower for both women and men than the control group (P < 0.01). In working group comparision among themselves, it is found that MRI workers have the lowest T-scores and conventional roentgen workers have the highest T-scores for both women and men. 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 4). Regarding the device they use, serum ALP levels of roentgen and tomography workers were lower than the control group meaningfully (p<0.05). Serum ALP levels of MRI workers were lower than the control group but there was not any meaningful difference on MRI workers (p>0.05) (Table 5).

DISCUSSION

In this study, We have demonstrated that exposures to low dose ionizing radiation and non-ionizing radiation have significant decreasing effect on bone mineral density of radiology workers. Likewise, exposures to low dose ionizing radiation have noteworthy decreasing effect on serum alkaline phosphatase levels of them. Varied in published reports, bone mineral density at femurs of dogs and mice exposed to radiation is lower and osteoporosis can occur (6,7). In addition, heavy ionizing radiation ((56)Fe) in lumbar spines of mices which

***Table 2**. Short time and one hour time of periode radiations measurement results in control room and shooting rooms.*

	First radiation dose	One hourly cumulative dose	n/s
Control 1	0,0019 mSv	0,0028 mSv	-
Control 2	0,0015 mSv	0,0023 mSv	-
Control 3	0,0018 mSv	0,0023 mSv	-
Roentgen 1	0,0022 mSv	0,026 mSv	1-2 /s
Roentgen 2	0,0025 mSv	0,052 mSv	1-2 /s
Roentgen 3	0,0020 mSv	0,024 mSv	1-2 /s
Tomography 1	0,0025 mSv	0,066 mSv	2-3 /s
Tomography 2	0,0026 mSv	0,074 mSv	2-3 /s

n/s: Time of techniciance coming into room after exposuring patient.

Table 3. DEXA results of radiology workers depending on the device they use

	BMD (T-Skor)	p Value
Control (n=40)	0.64±0.68	
Roentgen (n=34)	-0,86±0,79*	p<0.01
Tomography (n=9)	-1,22± 0,57*	p<0.01
MRI (n=6)	-1,68±0,57**	p<0.01

(*) p<0.01 According to control group. (**) p<0.01 According to control and conventional roentgen groups

Table 5. Serum ALP parameters depend on the device use of groups

	ALP (U/L)
Control(n=40)	97.88±37.66
Roentgen	85.96±28.51*
Tomography	66.14±14.76*
MRI	97.50±10.15

(*) p<0.01 According to control group.

are exposed to radiation caused bone mineral density decrease in L4 one month later (8). 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. Even if radiation is in low doses, long-term exposure to radiation decreases bone mineral density. Because of continuing irradiation, organism can not repair damages on body until next irradiation and damages accumulate (9).

Tomography workers were effected more than conventional roentgen workers because compared with conventional roentgen workers tomography workers are exposed to more radiation. For example, x-ray doses (tissue dose) approximately is 0.01–0.15 mGy in lung conventional roentgen graphy but it is 10–20 mGy in toraks CT. Even if this dose approximetely 80 mGy in CT coronary-angiography with 64 section (10), one tomography radiation dose is equal to approximately 400 lung roentgen graphy dose. In our study, it shows that lower bone mineral density in tomography workers is parellel with this results. The more radiation doses increase, the more the damages occcur for radiology workers and patients.

In terms of the device they use, bone mineral density of MRI workers decreases more than the others and radiation is more effective on men. Mri device is different from other devices by radiation kind. MRI device, works with radio frequency (RF) radiation and it causes electromagnetic field radiation. In literature, low frequency electromagnetic wave is used in order to heal bone fractures and to increase bone mineral density (11,12). But in these studies, it has been showed that electromagnetic wave is used in medicine by low frequency and pulse (15-72 Hz) (13). High frequency electromagnetic wave show opposite effect. Atay at al. (13) showed that 900-1800 MHz mobile phone causes meaningfully a decreased bone mineral density on iliac bone wing. These studies showed that high frequency electromagnetic radiation decreases bone mineral density of MRI workers. That is, low frequency electromagnetic radiaiton causes healing on bone mineral density but high frequency electromagnetic radiation causes damage on bone mineral density.

It has seen that bone mineral density decreases after therapeutic irradiation. It is concidered that missing of bone mass occur because of the bone osteoblastic formation and bone vasculature damages (14-16). Ionizing radiation inhibits osteoblast proliferation, increases sensitivity to agents that induce apoptosis, and reduces collagen production (17-19). After exposure to radiation, quantity of osteoblast in first month decreases progressivly (20,21). ALP is synthesized by osteoblasts and ALP is a very sensible test to show osteoblastic activity.

Table 4. DEXA results depend on the device use of groups (depending on sex)

	Control	Roentgen	Tomography	MRI
Female, n	21	17	6	3
T-Skor	0.44±0.46	-0.55±0.83*	-1.03±0.59*	-1.38±0.59*
Male, n	19	17	3	3
T-Skor	0.86±0.81	-1.17±0.63*	-1.61±0.27*	-1.99±0.43*

(*) p<0.01 According to control group.

In our study, serum ALP levels are low and it supports this information. After radiation exposure osteoclastic activity increases (22) and bone mass volume and density decrease for this reason. Osteoclasts are responsible cells for bone resorption. Osteoclasts resorbe bone mineral matrix and hydrolise organic matrix by enzymes.

Results of this study is similar to other various reports. In radiology workers, decrease of bone mineral density may depend on one or other factors we said before or their combined effects. Because of their significiant advantages to diagnose diseases, radiology devices are being used more and more. Like other technological developments, these developed devices have negative effects on patients and radiology workers health. It was found out that radiation has decreasing effect on bone mineral density of radiology workers and these decreases depending on sex and the device they use. 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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