EJSS
European Journal of Surgical Sciences

Eur J Surg Sci 2014;5(3):103-107

ORIGINAL ARTICLE

An Occupational Hazard in Orthopedic Surgery: Ionized Radiation

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ABSTRACT

Introduction: *Fluoroscopy and direct radiography are frequently used assistive methods in diagnosis and treatment in orthopedic surgery. In this study, over a period of one month, a dosimeter was placed under the lead apron and on the unprotected dominant arm of surgeons using an intraoperative lead apron, and thus, it was aimed to determine the dosage received and whether or not that dosage was within the permitted limits.*

Materials and Methods: *In this study, operations were monitored for radiation exposure for one month. Two thermoluminescent dosimeters were attached to the surgeon, one on the dominant upper extremity and the other under the lead apron. The radiation doses were measured in millirem and recorded at the end of one month.*

Results: *In the defined period of one month, there were fifty-seven orthopedic and traumatology operations. Fluoroscopy was used in eight of these operations. The measurements of the dosimeters under the lead aprons and on the arms of the surgeons were performed by the Atomic Energy Institution of Turkey. The numbers read on the dosimeters on the arms of the surgeons were in higher values than those under the lead aprons.*

Conclusion: *Our findings showed that although radiation exposure during orthopedic operations is below the recommendations of the Atomic Energy Institution of Turkey, it should become a standard for orthopedic surgeons to be given a dosimeter. Hence, the rights defined for other branches dealing with ionized radiation will also be provided for orthopedic surgeons.*

Key words: *Ionized radiation, Orthopedic surgeon, Occupational hazard*

Received: November 22, 2014 • Accepted: December 22, 2014

ÖZET

Ortopedik Cerrahide Mesleki Tehlike: İyonize Radyasyon

Giriş: *Ortopedik cerrahide floroskopi ve direkt röntgenogram tanı ve tedavide sıklıkla kullanılan yardımcı yöntemlerdir. Bu çalışmada 1 ay süresince intraoperatif kurşun gömlek kullanan cerrahın korunmasız dominant ekstremitesine ve kurşun gömlek altına yerleştirilen dozimetre ile aldığı dozlar belirlenerek izin verilen sınırlar içinde olup olmadığı araştırıldı.*

Materyal ve Metod: *Bu çalışmada 1 ay süresince yapılan ameliyatlar ve dozlar kaydedildi. Ortopedik cerraha biri dominant üst ekstremitesine diğeri kurşun gömleğin altına yerleştirilmek üzere 2 adet termolüminesans dozimetre takıldı. 1 ay sonunda radyasyon dozu milirem olarak kaydedildi.*

Bulgular: *Tanımlanan 1 aylık sürede 57 ortopedi ve travmatoloji ameliyatı gerçekleştirildi. Bu ameliyatların 8'inde floroskopi kullanıldı. Bir ayın sonunda cerrahın ekstremitesindeki ve kurşun gömleğin altındaki dozimetrelerin ölçümleri Türkiye Atom Enerjisi Kurumu tarafından gerçekleştirildi. Cerrahın ekstremitesindeki dozimetrede okunan rakamlar kurşun gömlek altındakilere göre daha yüksek değerde idi.*

Sonuç: *Yapılan çalışmalarda ve bizim çalışmamızda alınan dozların Türkiye Atom Enerjisi Kurumunun belirlediği dozların altında olsa da iyonize radyasyona sürekli maruziyet sonrası görülen deterministik etkiler açısından ortopedik cerrahların dikkatli olması gerektiği aşikardır. Ortopedik cerrahlara dozimetre verilmesi standart hale getirilmeli, iyonize radyasyonla uğraşan diğer branşlara tanınan haklar ortopedik cerrahlara da sağlanmalıdır.*

Anahtar kelimeler: *İyonize radyasyon, ortopedik cerrah, mesleki tehdit*

Geliş Tarihi: 22 Kasım 2014 • Kabul Ediliş Tarihi: 22 Aralık 2014

INTRODUCTION

Fluoroscopy and direct radiography are frequently used assistive methods in diagnosis and treatment in orthopedic surgery. In recent years in particular, the development of minimally invasive techniques in orthopedic surgery, and the increasing use of fluoroscopy associated with it have created a threat in terms of the effects of ionized radiationin orthopedic surgeons. That the regulations in Turkey for dosage and duration of radiation applied do not provide adequate protection for orthopedic surgeons is one of the most significant current problems.

In this study, over a period of one month, a dosimeter was placed under the lead apron and on the unprotected dominant arm of the surgeons using an intraoperative lead apron, and thus, it was aimed to determine the dosage received and whether or not that dosage was within the permitted limits. The aim of the study was to determine the dose of ionized radiation that the surgeons were exposed to intraoperatively even with the protection of a lead apron, and to determine what additional precautions could be taken.

MATERIALS and METHODS

In the Orthopedic and Traumatology Clinic of Ankara Numune Training and Research Hospital, for a period of one month, a record was kept of the number and type of operations performed by or included orthopedic surgeons that required intraoperative fluoroscopy and radiography, the number of radiographs taken, the dosage used, the duration of fluoroscopy use, and the number of fluoroscopy images. For the study, two thermoluminescent dosimeters (Panasonic UD-802AS2) were attached to the surgeon, one on the dominant upper extremity and the other under the lead apron.

For a period of one month, two different fluoroscopy devices (Ziehm 8000, Germany and kmc-950, Comed Medical Systems, Korea) and one mobile radiograph machine (Shimadzu, Japan) were used by two radiology technicians. Calibration of the machines was made before the study. Although the fluoroscopy machine varied between 50-67 Kv and 1.5- 3 mA according to the area of surgery, it was used at the dosage defined by the technician. The mobile radiograph machine ranged between 45-65 Kv and 1.2-3.5 mA, and was also used at the dosage defined by the technician.

The lead aprons used by the surgeons had the properties recommended by the Atomic Energy Institution of Turkey and had passed the required tests. In order to position and manipulate the patient for intraoperative use of fluoroscopy and radiography, the surgeon was approximately 30-70 cm from the patient. In operations using fluoroscopy, postoperative radiographs were taken by the same surgeons.

RESULTS

In the defined period of one month, there were fifty-seven orthopedic and traumatology operations. Fluoroscopy was used in eight of these operations (Table 1). At the end of one month, a total of 123 radiographs and 930 fluoroscopic images were taken. The total duration of fluoroscopy use was 31.5 min. The number of fluoroscopy images and duration of use were recorded according to the operation (Table 2). The measurements of the dosimeters under the lead aprons and on the arms of the surgeons were performed by the Atomic Energy Institution of Turkey (Table 3). The numbers read on the dosimeters on the arms of the surgeons were in higher values than those under the lead aprons. The values on the extremities were observed to be below the "Radiation Safety Management" data reported by the International Commission on Radiological Protection and the Atomic Energy Institution of Turkey, Nuclear Research Centre.

Table 1. Operations performed and imaging methods used

Diagnosis	Operation	No of operations	No of radiographs	No of fluoroscopy images	Duration of fluoroscopy use (mins)
Coxarthrosis	Total hip prosthesis	4	8		
Gonarthrosis	Total knee prosthesis	5	10		
Aseptic loosening of hip prosthesis	Revision hip prosthesis	1	4		
Aseptic loosening of knee prosthesis	Revision knee prosthesis	1	4		
Femur head AVN	Core decompression	3		30	2
Halluxrigidus	Arthrodesis	1	2		
PEV	Posteromedial loosening	1	4		
Humerus fracture	Plate-screw osteosynthesis	2	8		
Forearm fracture	Plate-screw osteosynthesis	5	10		
Distal radius fracture	Percutaneous fixation	6	12	60	2
Pelvis fracture	Plate-screw osteosynthesis	1	3		
Femoral neck fracture	Hemiarthroplasty-cannulated screw	6	12	40	1
Intertrochanteric fracture	PFN	7	14	360	10
Femoral shaft fracture	Intramedullar nailing	2	8	100	4
Malleolar fracture	Cannulated screw-plate-screw osteosynthesis	3	6		
Tibia fracture	Intramedullar nailing	4	8	160	8
Calcaneus fracture	Cannulated screw	3	6	60	1.5
Femur pseudoarthrosis	Intramedullar nailing	2	8	120	3

AVN: Avascular necrosis, PEV: Pesequinovarus, PFN: Proximal femoral nail.

Table 2. Number of fluoroscopic images and duration of use

Operations applied with fluoroscopy guidance	No of fluoroscopy images	Duration of fluoroscopy use
Femoral head AVN	10 ± 2	40 ± 20
Distal radius fracture	10 ± 3.4	20 ± 5.4
Femoral neck fracture	20 ± 7	30 ± 14.1
Intertrochanteric fracture	52 ± 19.9	85.7 ± 40
Femur fracture	50 ± 14.1	120 ± 42.4
Tibia fracture	40 ± 7	105 ± 26.4
Calcaneus fracture	20 ± 5	30 ± 10
Femur pseudarthrosis	60 ± 14.1	90 ± 14.1

Table 3. Measured doses

Dosimeters	Radiation dose (millisievert)
Dominant extremity	0.23
Under the lead apron	0

DISCUSSION

Together with the current developments in minimally invasive techniques, fluoroscopy and direct radiography have become an integral and necessary component of orthopedic surgery. The use of these methods has had significant effects on orthopedists[1]. There are studies in the literature related to the amount of radiation to which orthopedists are exposed in orthopedic surgery[1-3]. As these studies have been short-term, there are limitations such as having been conducted with a single procedure. The current study also had the limitation of the measurements being made over a period of one month.

The radiation dose accepted for the whole body reported by the statement on Radiation Safety of the ICRP and the Atomic Energy Institution of Turkey, Nuclear Research Centre is 5000 mrem, and should be below mean 2000 mrem in five consecutive years. The acceptable maximum dose throughout a year defined by the ICRP is 50 mSv (millisievert) (5 rem) for the whole body, head, neck, gonads, eyes, and bone marrow; 750 mSv (75 rem) for the extremities, hands and feet; and 15 rem for the thyroid. It has been reported that a dose of 200 rem (200.000 mrem) may lead to cataracts[4].

Several studies have shown that the use of protective equipment like lead aprons to avoid the harmful effects of radiation protects against the effects of radiation. In those studies, the monthly dose have reached a maximum of 7 rem under a lead apron. At the same time, it has been determined in the same studies that a maximum dose of 245 mrem reach beyond the lead apron[5,6]. In the current study, the monthly dose under a lead apron was determined as 0mSv, and the dose in the dominant extremity was 0.23 mSv. This dose was seen to be below the permitted levels. However, although lead aprons and thyroid protective equipment are available in many centres, it can be difficult to obtain protection for the extremities and radiation protective glasse seven in central hospitals.

According to item 7 of the Management of Radiation Dose Limits for Personnel Working with Sources of Ionizing Radiation in Healthcare, it is emphasized that the use of a wrist or ring dosimeter is necessary in addition to the routine dosimeter for personnel using fluoroscopy[7]. Despite these guidelines, many orthopedic surgeons still do not routinely use a dosimeter.

Personnel is affected by radiation in three ways; direct, reflected and leakage. The leakage effect is related to the use of the fluoroscopy device, and reflection is from the patient's body or is created by transfer from parts of the operating theatre[4,8]. After exposure to ionized radiation, two types of effects are seen in the organism. The first is the Deterministic effect and the second is the Stochastic effect. The deterministic effect resulting from exposure to large doses of radiation causes cell death. The stochastic effect is the development of metaplasia in the cells after long exposure at a dose which does not cause cell damage. This metaplastic change may develop into malignancy after a long period. These effects may result in the development of cell mutation, chromosomal impairments, thyroid cancer, sterility, and cataracts[9]. As orthopedic surgeons are exposed to the stochastic effect throughout their working life, there is an increased possibility of the above-mentioned problems.

Another important point in the protection against radiation is the distance from the light source. In a study by Mehlmann et al., the safe distance from the light source has been found to be 46-90 cm while Taflbafl et al. have reported a safe distance to be 150 cm[10,11]. In a study by Çeçen et al, radiation has been determined in dosimeter measurements even at a distance of 200 cm, whereas Giachino has stated that a distance of 45.7 cm from the light source is sufficient for protection[4,12]. In most operations, orthopedic surgeons have difficulty in maintaining distance from the fluoroscopy device during fracture reduction and manipulation. In the current study, the surgeons were 30-70 cm away from the light source. Especially when positioning an extremity or in cases where minimally invasive surgery is applied, the contact between the surgeon and the patient creates a significant increase in the received dosage in both direct and reflected form.

Apart from the orthopedic surgeon, the other personnel in the operating theatre are exposed to ionized radiation just as the physicians are. In addition, both data and preventative measures are in adequate for the other personnel in terms of the effects of ionized radiation. In a study by Vural et al, it has been determined that although theatre nurses were aware of thyroid protectors, only 39% of other personnel apart from nurses were aware[13]. Training must be provided and necessary precautions must be taken in respect of the effects of ionizing radiation for these personnel.

Even though the doses of the present and previous studies are below those defined by the Atomic Energy Institution of Turkey, it is obvious that orthopedic surgeons should take care in respect of the deterministic effects seen after continuous exposure to ionized radiation. Especially in hospitals where the use of fluoroscopy is widespread, appropriate protective equipment must be provided for the personnel other than orthopedic surgeons. This is an indispensable step in health and safety of all employees at work. It should become a standard for orthopedic surgeons to be given a dosimeter. Hence, the rights defined for other branches dealing with ionized radiation will also be provided for orthopedic surgeons.

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