Deanship of Graduate Studies

Al-Quds University

Radiation effective dose measurement for medical staff during orthopedic surgery at Hebron Governmental Hospital

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Thesis Approval

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Jerusalem

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Dedication

To My lovely Father

The greatest man in my life, for earning an honest living and for us, who supported and encouraged me to believe in myself.

My lovely Mother

The biggest heart with the most loving care, who sacrificed a lot for me to become what I am now.

My Wife

The wonderful person who supported me throughout this journey, and who was the greatest source of inspiration, my beloved Wife "Alaa".

My Daughters and son

To the light of my eyes, my kids " Zina, Rawd & Sufia "

I dedicate this research to all those who encouraged, supported, and helped me all the way I would like also to extend my deep appreciations to all those who contributed to the completion of this thesis.

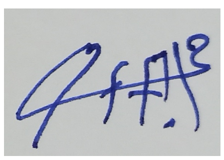
I dedicate my effort to all whom I love …

Ahmad Abdelkreem Farjallah

Declaration:

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise is acknowledged, and that this study (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Ahmad Abdelkreem Ismail Farjallah

Signed: 

Date: 1/6/2020

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Radiation effective dose measurement for medical staff during orthopedic surgery at Hebron Governmental Hospital

Abstract

The study aims at identifying and estimating the radiation does exposes by orthopedic specialist, nurse and anesthetist technician during performing surgeries to pelvic fractures with the assistance of the x-ray machine (C-arm). The study's hypothesis stated that the orthopedist and medical staff are exposed to high levels of radiation, even though they are not considered as Radiation Workers (RWs). The radiation was monitored by using the Thermoluminescent Dosimeter "TLDs" that store the amount of radiation exposure and then measure it.

TLD was placed on the chest area under the lead apron at the level of the center of the body to record the amount of radiation exposure of the whole body. The study was conducted on three workers in the Orthopedic Operation Theatre, and they are: the orthopedic specialist , nurse and anesthesia technician. The total number of surgeries conducted was 21 pelvic fractures fixations . The amount of x-rays exposure during the period of two months was as follows: 0.36 mSv for the orthopedic specialist, 0.34 mSv for the nurse, while the anesthetist technician was the least exposed to radiation with 0.21 mSv. As for the study findings, it becomes clear that the annual dose of exposure for orthopedic staff can reach more than 1.28 mSv only during one type of operation.

In general, the orthopedic specialist who performs pelvic surgeries is exposed to a high dose of radiation, which affects the endocrine and body cells. since the amount of radiation exposure exceeds 10% of the maximum permissible radiation dose for medical imaging staff (20 mSv per year), orthopedic specialist and his team should be classified as radiation workers and they must be monitored radiologically on a regular basis because I do not know the harmful effects of this small dose on the human body.

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List of Abbreviations and Units

Abbreviation	Meaning
ALARA	‘‘As Low As Reasonably Achievable’’
DCS	Dynamic Condylar Screw
DHS	Dynamic Hip Screw
DNA	DeoxyriboNucleic Acid
ED	Effective Dose
ESAK	Entrance Surface Air kerma
ESD	Entrance Surface Dose
ICRP	International Commission on Radiological Protection
KVp	Killo-Voltage peak
Ma	Milli Ampere
MAs	Milli Ampire second
MGy	Milli Gray
MoH	Ministry of Health
MSv	Millisievert
TLD	Thermoluminescent Dosmieter

Chapter One

Introduction

1.1 Historical Background

William Rontgen discovered X-ray was in 1985, and consequently this discovered has led to a revolution in medicine. X-ray can penetrate human body (possesses high ionizing capability), so it can cause damage or change DeoxyriboNucleic Acid (DNA) and make cancer. Moreover, the risk that orthopedic surgeon may develop cancer (e.g. thyroid carcinoma) is significantly higher than that of a non-orthopedic professional, and it is eight times more than that of an unexposed worker. (Miller, 2009). Interventional fluoroscopy presents a tremendous advantage over invasive surgical procedures, because it requires only a very small incision, which substantially reduces the risk of infection and allows for shorter recovery time compared with surgical procedures. (Moore & Heeckt, 2011).

C-arm fluoroscopy real-time imaging is used in orthopedic skeletal for system surgery. It decreases invasive surgery, especially for the visualization of orthopedic implant placement and fracture reduction.

A C-arm is an imaging scanner intensifier (Fig.1). The name is derived from the C-shaped arm used to connect the x-ray source and x-ray detector to one another. C-arms have radiographic capabilities, although they are used primarily for fluoroscopic intraoperative imaging during surgical, orthopedic and emergency care procedures since X-ray ionizing photon is frightening, newly C-arm became very important and used in all orthopedic surgery therefore all radiation worker must protect themselves during interventional operation. As a result the dose of radiation, not uniform must be assessed because it may be high.

Consequence, the areas of the body which are not protected by the lead apron, may receive significant radiation doses from scattered X-rays. (Kim et al., 2009).

Orthopedic surgery staff exposed to scattered radiation during procedure, their anatomical parts, such as the eye, thyroid, and skin are not well protected from radiation. The lack of radiological protection training in radiation science, or the protection measure for those who work with fluoroscopy outside imaging department can increase the radiation risk to both staff and patient. Radiation dose in interventional procedures must be controlled by offering protection from x-ray during imaging, and by using protective tools and dosimetry assessment. It's also recommended to measure occupational and patient radiation doses in interventional procedures . (ICRP 2009).

Methods to reduce radiation exposure in clinical practice are well known. They include increased distance from radiation source, decreased radiation exposure time, and shielding. Shielding protection is typically achieve by using lead garments such as the lead apron, which can attenuate 90% of the radiation with the common thickness of 0. 5 mm. (Bushberg et al., 2011).

The International Commission on Radiological Protection (ICRP) derive the limit of an average of 20 $mSvy^{-1}$ over five years for the occupational dose limit and 1 mSv y^{-1} for the public dose limit.

The biological effect of radiation on humans is terrifying, The fluoroscopes emit doses of approximately 5 rads per minute, and mini fluoroscopes can cause serious and irreversible damage to health. It is known that doses of 1 rad, when applied systematically to a given region, can cause damage to (DNA) and consequently would led to cancer, at proportions of approximately 1:100,000. It is important to emphasize that, in the human organism, ionizing radiation inhibits cell mitosis and irreparably breaks the DNA's double chain. Nuclear structural modifications produce severe alterations to cells and increase the chances of potential genetic transmission of such errors. Hands, thyroid, eyes, abdomen and genitals are critical target areas that should receive proper care. (Palacio et al. 2014).

1.2 Problem statement

C-arm became very necessary in orthopedic surgery because its offer a lot of details and help in decreasing of bleeding and infection. In this surgery, orthopedic staff used C-arm without any knowledge about radiation effect and lateen risk. The amount of radiation exposure may be disastrous to the staff when the doses is very high because it may be cause cancer .The amount of dose depend on the number of acquired images and the time of fluoroscopy, which is used morally in orthopedic surgery.

Fig.1 A C-arm machine.

Radiation dose measurement is required since there is no enough assessment made at the national level to estimate the radiation doses to the patient and staff.

Unfortunately the measurement of staff and patient dose in orthopedic surgery is poorly studied in Palestine.

The radiation protection awareness among, orthopedic staff workers is not sufficient to protect them from high radiation, and it may be the reason behind the high exposure of staff in interventional orthopedic surgery, which turn to causes lifetime cancer risk.

1.3 Objectives

The study aim at measuring the radiation dose to staff during interventional orthopedic procedure Dynamic Hip Screw (DHS) surgery if it is within the acceptable level compared with the international limits. Additionally it aim at evaluating the level of radiation protection to reduce radiation dose to the staff during interventional orthopedic surgery in Hebron Governmental Hospital in Palestine.

Chapter Two

Literature Review

2.1 Introduction

The optimization of radiation protection in the interventional radiology is a research area. Different results are determined and several ideas are recommended to protect the radiation worker and achieve the ‘‘As Low As Reasonably Achievable’’ (ALARA) principle.

2.2 Dynamic Hip Screw (DHS) procedure:

The Dynamic Hip Screw (Fig 2.1) is designed for the fixation of certain types of proximal femur or hip fractures. The screw is a large cancellous lag screw that can glide freely in a metal sleeve. The sleeve is attached to a plate, which is fixed to the lateral femoral cortex with screws. Weight bearing thus causes the femoral neck to impact on the femoral metaphysis, producing dynamic fracture compression. This movement is only allowed in one plane along the sleeve, maintaining fracture reduction. As bone responds to dynamic stresses, it is intended to promote remodeling and fracture healing. Fig 2.2 shows a hip fracture fixed by DHS.

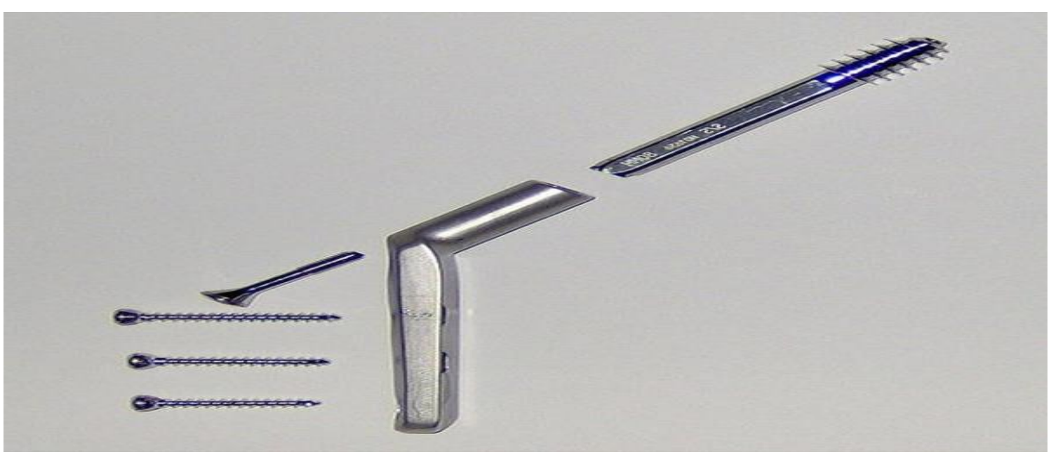

Fig.2.1 An example of a dynamic hip screw.

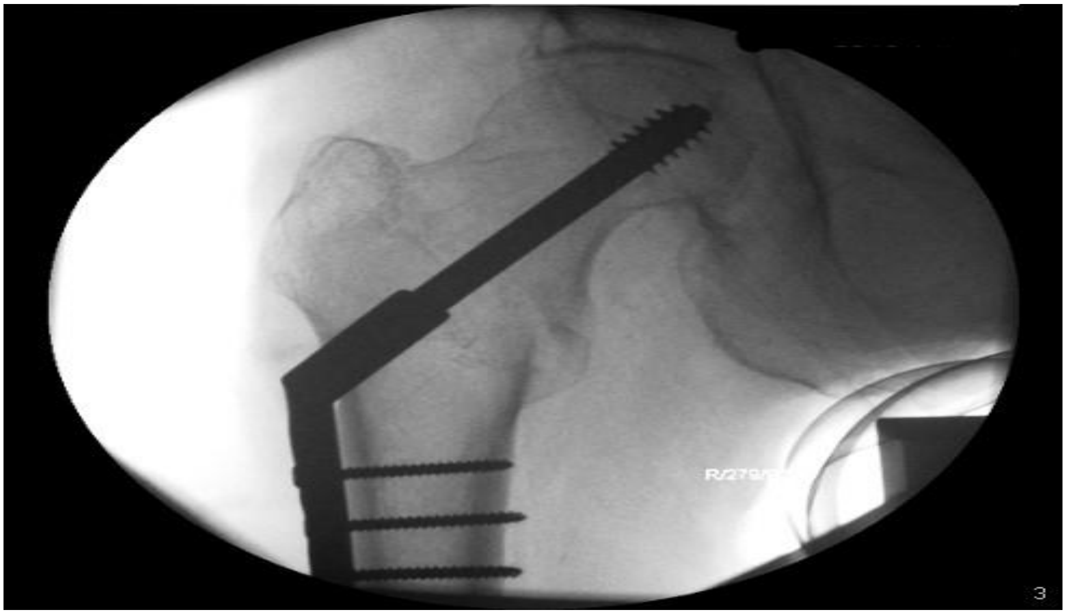

Fig 2. 2 An example X-ray of a hip fracture that has been fixed by a dynamic hip screw.

DHS are a femoral head-sparing orthopedic device used to treat femoral neck fractures. It is sometimes referred to as a pin and plate. The complications can be detailed as follow :

- Infection
- Hematoma
- Nonunion or malunion
- Implant complication, e.g. screw or plate fracture (2%)
- Osteonecrosis

https://www.touchsurgery.com/simulations/dynamic-hip-screw-2/2019

Key Anatomy

Proximal femur or hip fractures can be classified either as intracapsular or extracapsular. Intracapsular fractures involve bone that is within the ligamentous hip joint capsule, and extracapsular fractures involve bone distal to the capsule. Intracapsular hip fractures can be graded according to severity by the use of Garden Classification System (Fig 2.3). There are four grades of severity:

I - Incomplete fracture.

II - Complete fracture (across the femoral neck) that is undisplaced.

III - Complete fracture that is partially displaced.

IV - Complete fracture that is totally displaced.

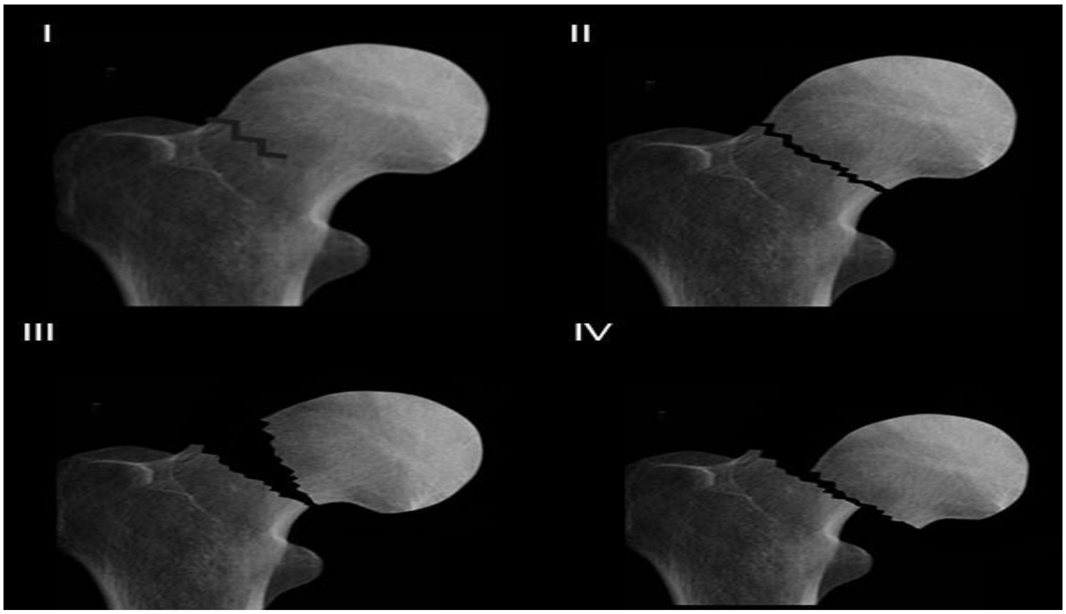

Fig 2.3 The Garden classification system (simulated images).

2.2.1 The Garden classification

The Garden classification relates to prognosis, as the more severely displaced the fracture is, the more likely the blood supply to the femoral head is compromised. The lateral hip X-ray can also facilitate to determine the extent of fracture displacement. Fracture displacement will lead to a higher risk of avascular necrosis of the femoral head.

Extracapsular fractures of the proximal femur include intertrochanteric fractures (between the greater and lesser femoral trochanters), and subtrochanteric fractures (distal to the trochanters). According to the Evan's Classification, intertrochanteric fractures can be graded as (Fig 2.4):

I – Non-displaced 2- part fracture.

II – Displaced 2- part fracture.

III – 3- part fracture with posterolateral comminution.

IV – 3-part fracture with posteromedial comminution.

V – 4-part fracture with comminution involving both trochanters.

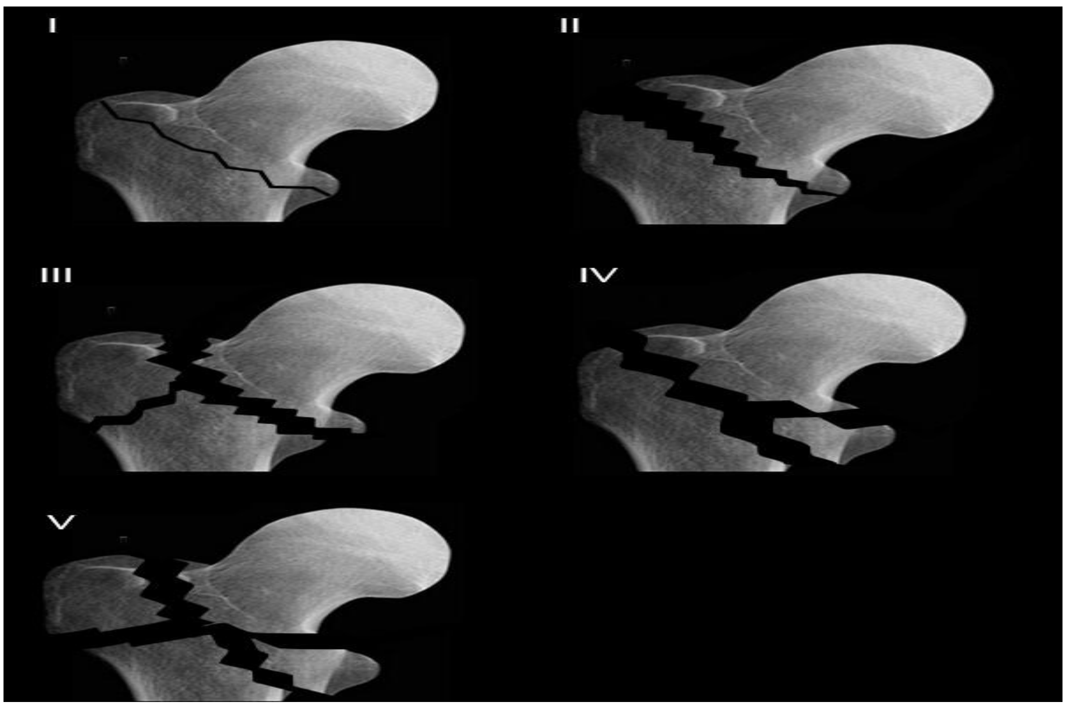

Fig 2.4 Evan's Classification of intertrochanteric fractures (simulated images).
https://www.touchsurgery.com/simulations/dynamic-hip-screw-2/2019

2.2.2 Indications

The DHS is used for intertrochanteric hip fractures, which are classified as binge stable and compressible. Unstable or reverse oblique fractures may require an alternative device. A DHS is also indicated for intracapsular hip fractures where the femoral head is likely to have maintained sufficient blood supply. This includes Garden type I and II fractures. It may also be appropriate for hip fractures of Garden type III and IV in young patients where there is a possibility that the blood supply may be preserved.

2.2.3 Patient Positioning

The patient should be positioned supine on a traction table, with both feet placed in traction boots, and the arms are placed over the chest. The image intensifier and display unit are positioned at the foot of the table where it can easily be brought in for imaging (Fig 2.5).

Fig 2.5 Table of DHS surgery
https://www.touchsurgery.com/simulations/dynamic-hip-screw-2/2019

2.3 Previous studies

One of the article aimed at determining the amount of radiation exposure in the orthopedic operating theater, to show that the radiation dose has decreased with distance from the tube. Four dosimeters were placed at the head and foot of the operating table.

At the end of 104 days, the total values were determined as 0.905 mSv at the foot of the table, 0.6817 mSv at the head of the table, 0.075 mSv at 200 cm from the foot of the table, and 0.0517 mSv at 200 cm from the head of the table. The rate of radiation determined in the dosimeters decreased when the distance from the radiation source increased. (Guyltekin et al 2015).

A Study about the dose in orthopedic surgery was conducted to measure the radiation dose on the patient and staff during (DHS) & Dynamic Condylar Screw (DCS). The dose was measured for the unprotected organ of staff and patient. The mean radiation dose for staff was higher in DHS than in DCS. For example in thyroid, the dose in DHS was 4.69 mSv and 1.21mSv in DCS. (Abdelmoneim et al 2014).

The radiation exposure on surgeon and assistants staff from a mini C-arm unit during fluoroscopically guided orthopedic surgeries was also investigated. During the direct observation, the skin-entrance exposure rates of the surgeon's hand, eye and thyroid gland were 8036, 0.85 and 0.9 mSv with 21 minutes, respectively. As for the scattered exposure rate, it was precipitously dropped beyond the path of the primary radiation beam, and reached 0.51 mSv with 21 minutes, at a distance of 40 cm from the beam's central axis. This study showed that the surgeon's hand was the most dose-limiting organ for fluoroscopically guided orthopedic surgery procedures. (Asghar mesbahi 2008).

A study in Khartoum conducted an evaluation of radiation safety and protection in interventional orthopedic procedures for the staff in three theatres. Integrity check was conducted on the available radiation protection tools (lead aprons) to ensure they provide optimal protection when positioned appropriately. The study showed an absence of most of the radiation protection and safety procedures that ensure the protection of workers, in addition to workers lack of awareness about radiation protection. Furth more, the average absorbed dose to orthopedic specialists falls within the acceptable limit according to the recommended of the International Commission of Radiation Protection (ICRP). (Mubarak Ibrahim 2014).

Sulieman et al (2014) intended to measure the radiation dose to patients and staff during (i) (DHS) and (ii) (DCS) and to evaluate Entrance Surface Air Kerma (ESAK) dose and organ doses, and effective doses. The means of patients' doses were 0.46 mSv and 0.07 mSv for DHS and DCS procedures, respectively. The mean staff doses at the thyroid and chest were 4.69 mSv and 1.21 mSv per procedure. Orthopedic surgeons were exposed to unnecessary radiation doses due to the lack of protection measures.

Aanother study conducted by (Rajaraman et al., 2016). Aimed at examining risks of cancer incidence and mortality among U.S. Nationwide, the prospective cohort of 90,957 radiologic technologists, who responded to a 1994–1998 survey which collected information on whether they had ever worked with fluoroscopically guided interventional procedures or not, was followed by completing a subsequent cohort survey during 2003–2005 (for cancer incidence). The analysis showed an approximately two fold increased risk of brain cancer mortality (HR, 2.55; 95% CI, 1.48–4.40), modest elevations in incidence of melanoma (HR, 1.30; 95% CI, 1.05–1.61), and in breast cancer incidence (HR, 1.16; 95% CI, 1.02–1.32). The researcher observed elevated risks of brain cancer, breast cancer, and melanoma among technologists.(Rajaraman et al., 2016).

However, orthopedic surgeons frequently utilize intra operative imaging; there is a lack of knowledge about their patterns of radiation protection. Thus the goal of this study was to fill this gap. Over 31% of surgeons are very concerned about their radiation exposure in their job while about 48% are slightly too moderately concerned. Nearly 65% of surgeons always wear a lead apron, but only 30.8% wear a thyroid protection. Lead gloves and lead glasses were always worn by only 2.5% (13/531), and 3.1% (16/531) respectively. Although most operating surgeons worry about their exposure, the knowledge. (Joeris et al., 2018).

Five cancer cases over 7 years were reported in a small orthopedic hospital. The study aimed at investigating whether workers subject to routine radiation dosimetric assessment in that hospital had an increased cancer risk. The cumulative 1976–2000 cancer incidence was 29 (9/31), 6 (8/125) and 4% (7/158) in orthopedics, exposed other than orthopedics, and unexposed workers, respectively. These findings warn against surgeons' underestimation of the potential radiation risk and insufficient promotion of safe work practices by their health care institutions. (Mastrangelo et al, 2005).

This study aimed at assessing the degree of exposure of the orthopedic surgical team to fluoroscopic ionizing radiation. The ionizing radiation to which the orthopedic surgical team (R1, R2 and R3) was exposed was assayed by using TLD that were distributed in target anatomical regions (regions with and without protection using a lead apron). This was done during 45 hip osteosynthesis procedures to treat transtrochanteric fractures that were classified as 31-A2.1 (AO). The radioactive dose received by R3 was 6.33 mSv, R2 4.51 mSv and R3 1.99 mSv ($p = 0.33$). The thyroid region received 0.86 mSv of radiation, the thoracic region 1.24 mSv and the gonadal region 2.15 mSv ($p = 0.25$). The members of the surgical team who were located closest to the fluoroscope received greater radiation doses than those located further away. (Palcio et al 2014).

The study of Tuncer et al.(2017) study aimed at evaluating the level of knowledge of orthopedic surgeons working in Turkey regarding the uses and possible risks of fluoroscopy. A questionnaire was sent to 1121 orthopedic surgeons working in Turkey. Among the surveyed surgeons, 313 (30%) had used fluoroscopy in over 50% of their operations. The average number of fluoroscopy shots per case was 54.5. Fluoroscopy shots were performed with the help of operating room personnel (86%). A dosimeter was used 5% of the time. However, orthopedic surgeons have inadequate knowledge about the uses and risks of fluoroscopy. The researcher, we believe that training on this topic should be provided to all orthopedic surgeons. (Tuncer et al 2017).

A study titled (A Quantitative Analysis of Ionizing Radiation Exposure to the Hands, Thyroid and Whole Body of Orthopedic Registrars At King Edward VII Hospital During Fluoroscopic Internal Fixation of The Lower Limbs). The hypothesis in this study was that the orthopedic specialist is not considered in the category of radiation workers. Hands received a dose of 0.22 mSv while the gland received 0.20 mSv and 0.010 mSv in each operation, and the monthly-received dose was 0.11 mSv. The received dose was more than 10 % of the annual radiology worker dose, which is "20 mSv per year", therefore orthopedic surgeons should be categorized as Radiation workers and should be monitored periodically.(Abu shab et al, 2006).

Chapter Three

Materials & Methods

3.1 Introduction

This study aims at measuring the radiation dose to the staff during DHS. Measurement of exposure dose was conducted by the use of TLD. The TLD used for this study Thermo Scientific TLD-100 Thermoluminescent Dosimetry Material consists of Lithium Fluoride (Li natural) LiF: Mg,Ti. Suitable for health and medical physics dosimetry applications. Required data were taken from the orthopedic team in operation departments in Hebron Governmental Hospital in Palestine.

3.2 Settings

The Measurements of effective dose for orthopedic staff was conducted at Hebron Governmental Hospital in the Palestine. Results are used to compare with other similar studies.

3.3 Research design

A quantitative study was chosen to achieve the objectives of study. Data were obtained by two-month records using TLD in orthopedic departments to measure the effective dose for the orthopedic staff Hebron Governmental Hospital in Palestine.

3.4 Study Population

The study population are the medical staff performing DHS surgery in Hebron governmental hospital during the period from 4/2019 – 6/2019. The data were obtained by direct measurements.

3.5 Study Sample

The surgical sample was just DHS. The orthopedic surgical team sample consists of three employees :

- ✓ **Orthopedic specialist**
- ✓ **Anesthesia Technician**
- ✓ **Nurse**

3.5.1 C-arm machine

In the present study one C-arm machine, was used. PHILIPS Model: CAS-10A, date of manufacturing: 2013, and the total filtration is 3 mm AL as shown in Fig.1.

3.5.2 Dose measurement

Radiation doses to surgical staff during DHS operation were measured by using the calibrated. The TLDs were sent to the MoH and was reading by HARSHAW TLD Reader 4500, The MoH calibrating the reader regularly. A total of 3 TLD were packed in plastic bags for the protection against any contamination in upper torso position, as shown in Fig 3.1. Chest dosimeter measures the dose under the lead apron. The TLD was placed at the upper chest level under shielded by the apron.

Three TLD dosimeters were kept permanently inside lead apron after every operation, protected from any external radiation that could compromise the results.

Fig 3.1 TLD place at the upper chest
https://www.aerb.gov.in/images/PDF/TLD.pdf/2020

The study related to measure the Effective dose E is defined as the summation of tissue equivalent doses, each multiplied by the appropriate tissue weighting factor W_T, to indicate the combination of different doses to several different tissues in a way that correlates well with all stochastic effects combined.

$E=\sum W_T \times H_T$

- W_T tissue weighting factor
- The unit of effective dose E is J/kg and its name is the sievert (Sv)(1).

3.5.3. Inclusion criteria:

DHS operation staff in Hebron Governmental Hospital will included during the period of two months between April to June 2019, if they meet the following criteria:

1. Permanent employee.

2. Part of orthopedic team surgery.

3.5.4. Exclusion criteria:

Medical staff in Hebron governmental hospital will not included during the period of two month between April to June 2019, if they meet the following criteria:

1. If they are not permanent employee.

2. If they are not part of orthopedic team surgery.

3.6 Study tool

The study tool used to assess the effective dose included:

3.6.1 Surgical file:

Data about surgery kVp and mAs, image number, and exposure time, were extracted from C-arm file for each participant in the study

3.7 Data collection

Data were collected by using a work sheet for all employs working in the orthopedic surgery operation room during the study period to ensure the consistency of the data .

3.7.1 Patient’s data collection:

Patient's data and factors used for effective dose (ED) include patient's sex, age and kVp, mAs and scanning length during every operation. Data were filled in specified self-designed worksheets, to obtain more accuracy and consistency.

3.8 Statistical analysis

Dose measurements required for effective dose were taken from TLD, and the ED was assessed per each TLD; collected data were used as an input to Microsoft Excel version 2007.

3.9 Obtained Approvals:

The approval from Palestinian Ministry of Health (MOH) was obtained to conduct the study in Hebron Governmental Hospital.

Chapter Four

Results and Discussion

DHS is considered a difficult fracture surgery. Also the radiation exposure to the medical team and patient is significantly higher compared with other surgeries. Dose monitoring during DHS procedures is mandatory to keep patient radiation risk as low as reasonable achievable.
As mentioned previously, the aim of this study was to provide staff dose measurement during DHS. Dosimetry was performed with TLD.

4.1 Results

4.1.1. Data of DHS surgery :

Table 4.1 provides a summary of patients DHS surgery :

Table 4.1: Data of patient DHS surgery.

Patient	Age (years)	Gender	Date	shot number	Dose (mGy)
A1	43	M	10.4.2019	200	24.3
A2	60	M	12.4.2019	25	3
A3	88	F	15.4.2019	40	5.7
A4	97	M	17.4.2019	40	5.4
A5	78	F	19.4.2019	45	6.1
A6	72	M	23.4.2019	50	7.2
A7	70	F	27.4.2019	65	8
A8	82	F	30.4.2019	52	7.3
A9	56	F	1.5.2019	50	7.4
A10	20	M	2.5.2019	40	4.5
A11	53	M	4.5.2019	40	5.9
A12	87	F	8.5.2019	80	10.2
A13	47	M	12.5.2019	50	6.6
A14	61	F	22.5.2019	40	5.1
A15	50	M	27.5.2019	41	5.3
A16	80	F	30.5.2019	50	7.7
A17	60	M	3.6.2019	50	7.3

A18	71	F	7.6.2019	71	9.2
A19	67	F	10.6.2019	221	27.4
A20	40	M	20.6.2019	50	8.1
A21	79	F	30.6.2019	50	7.8

Table 4.2: Exposure parameters

Parameter of C-arm	
KVp	72
MAs	16

4.1.2 Radiation exposure to the whole body:

Each orthopedic team worn TLD under the lead apron to obtained the radiation dose. This TLD was worn during DHS procedures performed within 2 months period. The mean radiation dose to the team whole body in two months was 0.36 mSv for orthopedic specialist, 0.34 mSv for nurse, and 0.21 mSv for anesthesia technician.(Table 4.3).|

Table 4.3 provides a summary of radiation dose measured by TLD in 21 DHS surgery:

Employer	ED (mSv)
Orthopedic specialist	0.36
Nurse	0.34
Anesthesia technician	0.21

4.2 Discussion

A total of 21 procedures were monitored over 3 months (April 2019 to June 2019). Fig 4.1 shows the dose fluctuations during the study period.

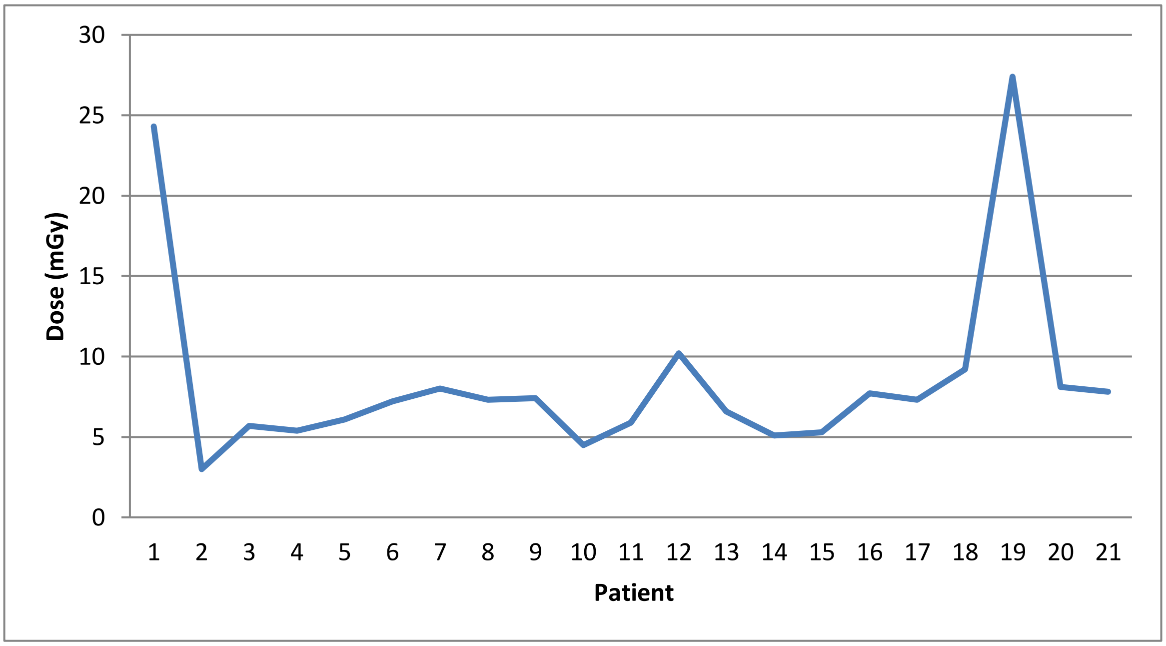

Fig 4.1 Relationship between Dose (mGy) and every procedure in DHS surgery.

Table 4.1 present the patient's data (age, file number, gender, dose (mGy), number of shot). The investigation of examination of the dose distribution revealed that 2 surgeries gave more than (24 mGy) Therefore, radiation dose optimization these two surgeries was very low as it can seen in (Fig 4.1). It was noted in the result of the study that surgery of patient number 1 and 19 received the highest amount of radiation. The reason for this result may be due to difficulty of the operation or experience of the staff.

4.2.1 Radiation Exposure to orthopedic team:

The TLD was placed at upper chest under shield .The whole body radiation doses to orthopedic team can be seen in figure 3.1. Among orthopedic surgery staff, orthopedic specialist received the highest dose with 0.36 mSv at 2 month during 21 DHS surgery. Nurses who work closely to the orthopedic specialist received 0.34 mSv at 2 month during 21 DHS surgery. Anesthesia technician received the lowest in the team dose with 0.21 mSv during 2 month in 21 DHS surgery.

Compared with previous studies, the effective dose of the medical staff for example, in a study(Abdelmoneim et al 2014), the effective dose was 1.21 during 56 DHS, while the effective dose in our study was 0.36 during 21 operations, and in both result the annual dose is high than the ICRP limit.

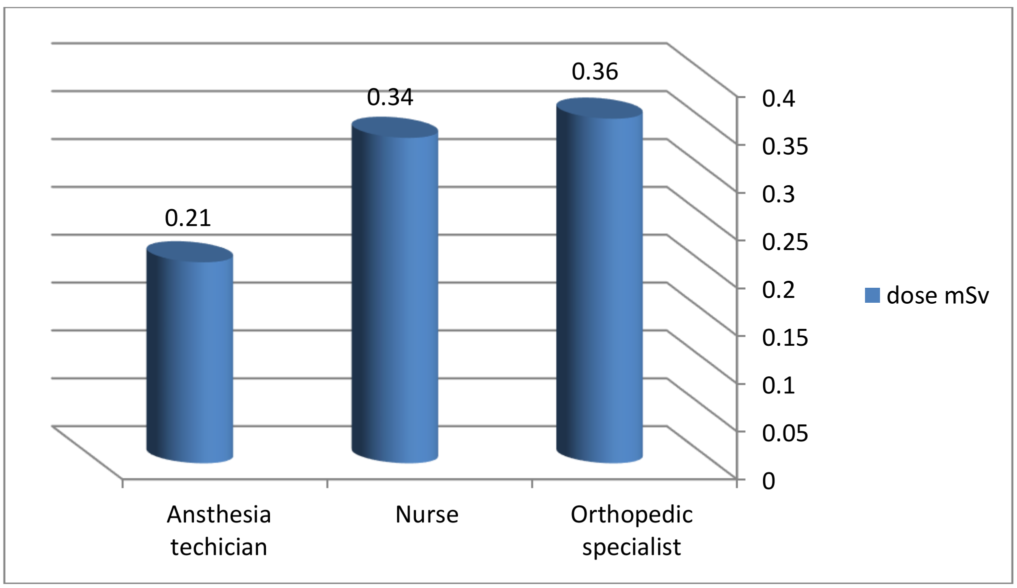

Fig 4.2 result of orthopedic team Examination doses

4.2. 2 Orthopedic specialist Dose:

The orthopedic specialist have the highest dose between the orthopedic team with 0.36 mSv per 21 DHS surgery. It is may be related to a small distance between the orthopedic specialist and the patient and so to radiation. If such a orthopedic specialist works the same way he/she would be exposed to about 2.16 mSv annually, the quantity that exceeds the annual dose mended in the ICRP.

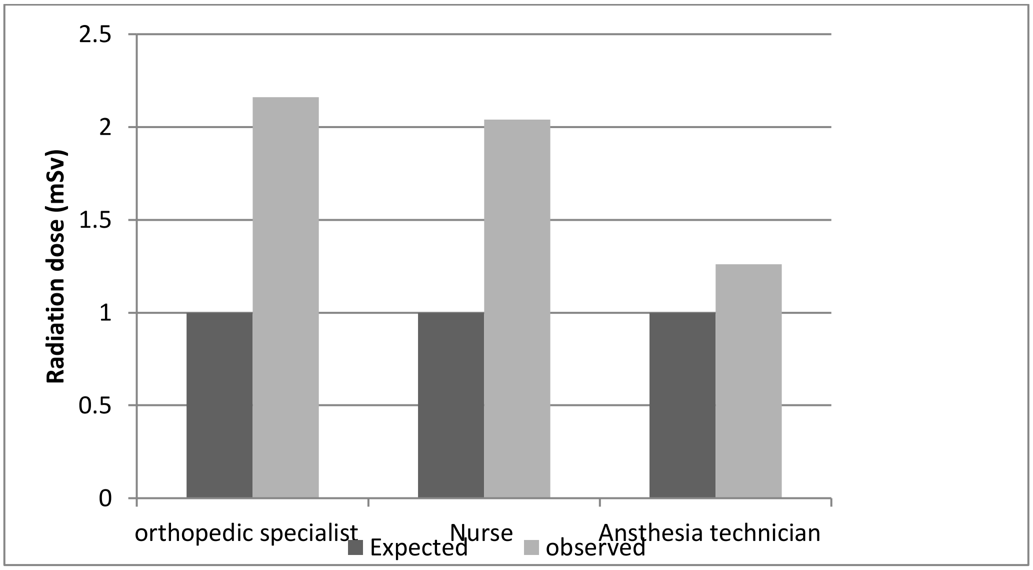

Fig 4.3 correlation between ICRP dose and Examination doses for staff.

4.2. 3 Nurse Dose:

As it can be seen in (Fig 4.2) the nurse received the second highest dose between the orthopedic team with 0.34 mSv per 21 DHS surgery. It is related to her direct work with the orthopedic specialist during DHS. If such a nurse works the same way, he/she would exposed to about 2.04 mSv annually. That exceeds the annual dose recommended in the ICRP

4.2. 4 Anesthesia technician

Related to (Fig 4.3) the anesthesia technician who received the lowest dose between the orthopedic team with 0.21 mSv per 21 DHS surgery. May be related to he /she is not always present in the operation room during the operation. If anesthesia technician performs such works the same way he/she must be exposed to about 1.26 mSv annually. which exceeds the annual dose recommended in the ICRP.

4.3 Study Limitations

There were few limitations in our study

1. The MoH does not have excess number of TLD for research.
2. The TLD is very expensive.

3. The high load of work in orthopedic surgery room by outer medical orthopedic surgery team.

4.4 Conclusion

Finally, the effective dose for medical team who perform DHS surgery is not within the ICRP recommendation level per year. There should be a safe way to deal during the DHS. The ALARA principle should be considered for any person working with radiation.

The team who performs orthopedic surgery absorbed more than the public limit. Orthopedic team surgery should be registered as radiation workers and be regularly monitored.

4.5 Recommendations

The study recommends the following:

1) Emphasize the necessity of wearing protective devices (shield , glasses, gloves, and thyroid protection).
2) Continuous scientific lectures for orthopedic specialist, nurse, and anesthesia technician about the risk of radiation dose and the mechanisms by which they can protect themselves.
3) Consider orthopedic medical staff as radiation workers with an annual dose of 20 mSv as certified in ICRP.

4.6 Future study

Future studies and research dosimetry for radiation dose levels should be conducted in Palestine to protect the medical team from high radiation dose and provide TLDs to check the dose annually and regularly.

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قياس الجرعة الإشعاعية التي يتعرض لها العاملون في غرفة عمليات العظام في مستشفى الخليل الحكومي في فلسطين .

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الملخص:

تم عمل الدراسة بهدف معرفة و تقدير كمية الأشعة التي يتعرض لها أخصائي العظام و والممرض وفني التخدير أثناء إجراء العمليات الجراحية لكسور الحوض بمساعدة جهاز الأشعة (C-arm) ، كانت الفرضية في هذه الدراسة بأن أخصائي جراحة العظام والطاقم الطبي يتعرضون لكميات أشعة عالية رغم أنهم لا يعتبرون من فئة العاملين في الأشعة.

تم مراقبة الأشعة باستخدام مجسات شعاعيه "TLDs" تقوم بحفظ كمية الأشعة المتعرضة لها ومن ثم يتم قراءتها. تم وضع المجسات في منطقة الصدر تحت الواقي الرصاصي على مستوى وسط الجسم لتسجيل كمية الأشعة المتعرض لها كل الجسم.

أجريت الدراسة على3 عاملين في غرفة عمليات العظام وهم : أخصائي العظام و الممرض وفني التخدير. إجمالي العمليات الجراحية كان 21 عملية لكسور الحوض. وكانت كمية الأشعة التي تعرض لها أخصائي العظام خلال شهرين 0.36 ميليسيفرت. بينما كانت كمية الأشعة التي تعرض لها الممرض 0.34 ميليسيفرت إما فني التخدير فكان الأقل تعرض للأشعة بواقع 0.21 ميليسيفرت .

من نتائج البحث اتضح انه يمكن أن تصل الجرعة السنوية للعاملين في قسم عمليات العظام إلى أكثر من 1.28 ميلسيفرت في العام خلال نوع واحد من العمليات فقط .

بشكل عام فإن أخصائي العظام , الذي يجري عمليات جراحية للحوض يتعرض إلي جرعة عالية من الأشعة تؤثر علي الغدد الصماء و خلايا الجسم و بما أن كمية الأشعة التي يتعرض لها تتجاوز إل % 10 من جرعة الأشعة القصوى المسموح فيها للعاملين في مجال الأشعة (20 مليسيفرت في السنة). لذلك يجب أن يصنف جراحي العظام , علي أنهم من فئة العاملين في الأشعة و يجب مراقبتهم إشعاعيا بصفة دورية، و ذلك لعدم معرفتنا بضرر هذه الجرعة الصغيرة علي جسم ا لإنسان.