Knowledge And Awareness of Radiation Safety Among Orthopaedic Surgeon: A Survey Analysis

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Research Article

Keywords: Radiation exposure, prevention, dosimeter, radiation safety, orthopaedic surgeons

DOI: https://doi.org/10.21203/rs.3.rs-412015/v1

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Abstract

Purpose: Orthopaedic surgeons are at potential risk to suffer from radiation exposure. The radiation exposure has increased due to minimal invasive and complex orthopaedic procedures. This study evaluates the level of knowledge of orthopaedic surgeons regarding radiation safety and prevention.

Methods: A survey consisting of 17 questions was conducted among the 519 orthopaedic surgeons. The orthopaedic surgeons were contacted via mobile or email and the data was analysed.

Results: Total of 542 responses were received and 23 were excluded due to incomplete responses. The result depicted, only 5% of the orthopaedic surgeons were aware of the ALARA/ALARP principles. Only 45% of the surgeons were right about the collimated image acquisition. None of the surgeon used dosimeter in the study. Most of the surgeons (40%) were not aware of the influence of C-Arm orientation on the scattered radiation. The protective gears were used by 75% of the orthopaedic surgeons and 5% used it occasionally. A lead apron is used by all the orthopaedic surgeons using the protective gear whereas only 15% used thyroid shield additionally. Only 5% of orthopaedic surgeons had some training in radiation safety and protection.

Conclusion: The study demonstrates the level of knowledge regarding radiation safety and consequences among orthopaedic surgeons. The study depicts the need for proper and appropriate training required by the orthopaedic surgeons. Further extensive and elaborate studies are required to ascertain the radiation safety as a part of the training programme of the orthopaedic surgeons.

Introduction

The use of fluoroscopy in orthopaedics is age-old and as well as inevitable. Various orthopaedic procedures are requiring the use of fluoroscopy leading to radiation exposure [1–3]. The risk of exposure has increased with the advent of minimal invasive and complex procedures. Radiation exposure remains a significant occupational hazard to the orthopaedic surgeon throughout their career [4]. It is utmost important to know about radiation safety and prevention. Surgeons are potentially at risk of side effects from the radiation. The study aims to assess the level of knowledge among orthopaedic surgeons.

Materials And Method

The study was conducted in 2020 with help of questionnaire formed in Google docs (Form 1). The Questionnaire was sent to the orthopaedic surgeon via mobile and emails. The study included all the orthopaedic surgeon including the residents, fellows and various other professors involved in various orthopaedic sub-specialities. The study was performed for over 3 months. Incompletely filled forms were not included in the study.

The questionnaire consisted of fifteen single option questions with two multiple option question. There was one image related question in the study. The question ranges from the descriptive data of the
surgeon and various questions regarding the knowledge of radiation safety and consequences. 542 orthopaedic surgeons participated in the survey but 23 were excluded due to incomplete forms. The data was analysed and depicted with help of pie charts and other diagrams in terms of whole numbers.

Results

The data was collected from the 519 filled forms by the various orthopaedic surgeons. The result depicted that 47% were junior residents, 35% were senior residents, 12% were assistant/associate professor and rest were professors. Few questions depicted the level of expertise of the surgeons in the study. The 55% of the surgeons operate 1–2 days per weeks whereas 40% operates for 3–4 days per week and rest 5% operates for 5–6 days per week. The study depicts the volume of surgeries done by the study population. The 60% of the surgeon performed 1–3 surgeries per operating day and 35% did 4–6 surgeries per operating days. Only 5% of the surgeons were performing 7–10 surgeries per operating day. The use of C-Arm is the main source of radiation in orthopaedic operating rooms. The study depicts 60% (312) of the surgeon did 1–2 surgeries requiring C-Arm per operating day. Only 5% of the surgeons used C-arm in 5–6 surgeries done per day and rest 35% of surgeons used C-Arm in 3–4 surgeries per operating day. The study demonstrates interesting data that 25% (130) of orthopaedic surgeons took >200 C-Arm images per operating day. This was inversely correlated to the experience of the surgeon (P > 0.005). Mostly (65%) the C-Arm is operated by the doctors and only 20% were operated by trained technicians. Only 5% (26) of the orthopaedic surgeons were aware of the ALARA/ALARP principles. The distance from C-Arm depicts 60% (313) of the surgeons were within 1 feet distance. Only 45% of the surgeon was right about the collimated image acquisition. None of the surgeon used dosimeter in the study. Most of the surgeons (64%) were not aware of the influence of C-Arm orientation on the scattered radiation (Fig. 1). The protective gears were used by 75% (390) of the orthopaedic surgeons and 5% used it occasionally (Fig. 2). A lead apron is used by all the orthopaedic surgeons using the protective gear whereas only 25% used thyroid shield and 3% used protective eye gear additionally (Fig. 3). The 90% (468) of the surgeons agreed that closed nailing surgery had more radiation exposure than the open nailing technique. The permissible limit of radiation exposure was known by 45% of the orthopaedic surgeons. The gonads were depicted as the most exposed part to scattered radiation by 45% of the surgeons, followed by the thyroid. Only 5% (25) orthopaedic surgeons had some training in radiation safety and protection.

Discussion

Ionising radiation is a potential risk factor for the various healthcare worker [4]. The most exposed medical professionals include cardiologist, orthopaedic surgeons and radiologists [5]. There are potential side effects of radiation exposure hazards ranging from dermatitis to malignant diseases [6]. In this study, the knowledge among the orthopaedic surgeon is evaluated regarding the safety and consequences of radiation exposures. Similar studies [7] were performed but none regarding the Indian population involving such questions. The use of intra-operative fluoroscopy is indispensable in most of the orthopaedic surgeries and procedures. With the advent of more complex and minimal invasive
surgeries, the use of fluoroscopy has increased many folds [8]. The surgeries like closed intramedullary nailing, MIPPO (Minimal Invasive Percutaneous Plate Osteosynthesis), Minimal invasive surgeries in the spine and so on has become standard and need of the hour. The 90% of the orthopaedic surgeons in this study agreed that closed femur nailing leads to more radiation exposure compared to open femur nailing technique (Question 14). There has been development in the fluoroscopy machines like C-Arm to provide 3D imaging intra-operatively. The Operating Room (OR) personnel including technicians and surgeons are exposed to such radiation risk on daily basis. But the surgeons, in particular, are unaware or ignore the radiation safety measures during surgical procedures. Although previous studies ascertained that the amount of occupational radiation exposure for surgeons who used C-arm fluoroscopy was below the safe limit determined by the International Commission on Radiation Protection [9, 10]. Still, it is important to have knowledge about radiation exposure and consequences.

In this study, we evaluated the knowledge of Indian orthopaedic surgeons regarding the protocols of radiation exposure, safety and consequences. The study involved various level of orthopaedic experts (trainees to professors) performing various types of surgeries in a different clinical setup. The surgeons in the study had varying operating days with different surgeries requiring C-Arm. Depending on the level of expertise as the type of surgery, the number of images taken by the C-Arm varies (Question1-5). The study correlated to the previous study [11] depicting the more experienced surgeon used a smaller number of fluoroscopy images thus reducing the radiation hazard.

The radiation exposure has both deterministic (dose-dependent) as well as stochastic (dose-independent) effects [12–14]. Although there is no deterministic effect seen among the orthopaedic surgeons but the stochastic effect can occur in the short or long term. The use of dosimeter for individuals exposed to a dose of > 6mSv annually is mandatory [9]. The study depicted no orthopaedic surgeon wore dosimeter while being exposed to the radiation (Question 10). It shows the lack of the surgeon as well as institutional support or aware regarding radiation safety. The dosimeter not only measures the level of exposure but also prevent the surgeon from overexposing. The study demonstrates that 25% of the surgeon took more than 200 C-Arm images per operating day. The surgeons are mostly exposed to the scattered radiation from the C-Arm. Thus, it is important to prevent this exposure rather than direct radiation exposure. This can be done using various methods.

Firstly, reducing the number of inappropriate images. Operating the C-Arm appropriately is important to reduce unwanted radiation exposure [15]. The trained personnel should operate the C-Arm to minimise inappropriate X-ray images. It not only helps to reduce the suboptimal exposed images but also inappropriate positioning of the C-arm. The study depicted that out of all the personnel operating the C-Arm only 20% are trained technicians whereas 65% are the doctors (Question 6). The scattered radiation from the C-Arm also depends upon the orientation of the machine. Mostly the C-Arm is oriented vertically with an X-ray tube below the operating table and image intensifier above the patient. This keeps the scattered radiation below the level of the operating table. The horizontal oriental orientation of the C-Arm produces more scattered radiation [16] and that too above the waist height of the surgeons. Thus, causing more radiation exposure to the persons in the operating room. Only 36% of the surgeons were
aware of this fact and mostly (64%) surgeons had no correct knowledge regarding this (Question 11). The collimation of the C-Arm also affects the amount of radiation [17]. Actively collimating to the volume of interest reduces the overall integral dose to the patient and thus minimises the radiation risk. Less volume irradiated will result in less X-ray scatter on the detector. This was well known to 45% of the surgeon in the study (Question 9).

Secondly, the use of protective gears by surgeons [18]. Studies have shown that the use of proper protection reduces a doctor’s radiation exposure by 90% [19]. This study demonstrates 75% of the orthopaedic surgeons used some kind of protective gears always while doing the surgeries. Whereas 25% of the surgeon did use some protective gear occasionally (Question 12). This may be accounted to the specialised orthopaedic procedures not requiring much C-Arm images or ignorance on part of the surgeons. All the orthopaedic surgeons (100%) used lead apron as the protective gear whereas only 25% used thyroid shield and 3% used protective eye gear additionally (Question 13).

Thirdly, the knowledge of radiation safety and consequences is utmost important. It was interesting to note that only 5% of the orthopaedic surgeon was aware of ALARA/ALARP criteria (Question 7). The ALARA (As Low As Reasonably Achievable) radiation safety principle is based on the minimization of radiation doses and limiting the release of radioactive materials into the environment by employing all reasonable methods [20]. ALARP (As Low As Reasonably Practical) is a process where the onus is to carry out measures to reduce radiation risk unless it can be demonstrated that it is not reasonably practicable to do so. This depicts the lack of training as most of the study population consists of residents. A greater distance from the radiation source can reduce radiation exposure [21, 22]. The amount of radiation exposure is inversely proportional to the square of the distance [23]. Due to the obvious nature of the occupation, 60% of the orthopaedic surgeons were within 1 foot of the C-Arm whereas rest were within 2–5 feet distance (Question 8).

The study revealed a lack of training among the orthopaedic surgeons regarding the radiation safety protocols. The International Commission on Radiological Protection [24] has established the standards for radiation protection including the dosage limits. Only 45% of the surgeons were aware of the permissible radiation exposure limits (Question 15). Whereas only 45% of the surgeons in this study pointed gonads as the most exposed part to the scattered radiation followed by the thyroid (Question 16). Previous studies depicted hands as most exposed part to the radiation though thyroid and gonads are sensitive to the radiation [25]. Whereas only 5% of the orthopaedic surgeon had training in radiation safety protocols (Question 17).

The study depicted the lack of adequate and appropriate knowledge among the Indian orthopaedic surgeons regarding the proper radiation safety protocols and consequences.

Limiting factor of this study: Small study population, study population does not depict the whole of orthopaedic surgeon population and more elaborate studies are required. The radiation hazard and long-term follow-up were not included in the study.
**Conclusion**

The study demonstrates the level of knowledge regarding radiation safety and consequences among orthopaedic surgeons. The study depicts the need for proper and appropriate training required by the orthopaedic surgeons. Further extensive and elaborate studies are required to ascertain the radiation safety as a part of the training programme of the orthopaedic surgeons.

**Declarations**

i. Funding (information that explains whether and by whom the research was supported): None

ii. Conflicts of interest/Competing interests (include appropriate disclosures): None

iii. Ethics approval (include appropriate approvals or waivers): Taken from Ethics Committee

iv. Consent to participate (include appropriate statements): Not applicable

v. Consent for publication (include appropriate statements): Not applicable

vi. Availability of data and material (data transparency): Yes

vii. Code availability (software application or custom code): Not applicable

viii. Authors’ contributions:

Dr Bushu Harna: Writing the manuscript

Dr Shivali Arya: Data collection

Dr Jaikaran: Data collection and writing the manuscript

Dr Palash Gupta: Data collection and writing the manuscript

Dr AK Gupta: Review the manuscript

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Figures

![Pie chart](image)

**Figure 1**

The pie chart depicting the surgeon opinion on the position of C-Arm and maximum scattering of X-rays.
Figure 2

The pie chart depicting the percentage of surgeons using protective gear while using C-Arm.

What do you use to protect yourself from radiation

| Gear Type              | Percentage |
|------------------------|------------|
| Lead Apron             | 100        |
| Thyroid Shield         | 25         |
| Eye Wear Protector     | 3          |
| Protection Gloves      | 0          |
| Leg Protector          | 0          |

Figure 3

The bar graph depicting the distribution of various protective gears used by the surgeons.