Radiation: Are We and Our Patients Protected Enough?

Among the many hazards that exist in the operating room, the radiation hazard to patients, surgeons, and operating room staff is a great concern. X-ray is an ionizing radiation that causes many pathologies, the most harmful being the development of malignant tumors. Although these are established facts, unfortunately, many orthopedic surgeons and operating room staff still do not take enough precautions to minimize radiation hazards to themselves and to patients they care for.

In a survey of cancer incidence, among 316 hospital employees over a period of 24 years, Mastrangelo *et al*.[1] determined that orthopedic surgeons had a significantly higher risk for cancer development ($P < 0.002$) compared to exposed other than orthopedics and unexposed workers.

The International Commission on Radiological Protection produced specific guidelines regarding radiation dosage for those exposed in occupational settings.[2]

In the Journal's previous issue (Vol. 5, Issue 1, January–March 2021), two papers discussed radiation hazards. One discussed how scoliosis patients are exposed to increased cumulative radiation doses during management and drew our attention to look carefully at methods to reduce radiation exposure to patients.[3] This is more important in the pediatric population as radiation may have more harmful long-term effects.[4,5] Indeed, we need to carefully look at the benefits and risks involved when requesting X-rays for patients in every orthopedic visit and should be very selective on how many images and views are needed initially, intraoperatively, and during follow-ups. In general, the principle of ALARA "As Low As Reasonably Achievable" should always be kept in mind while requesting or using radiation.[6] On initial assessment after trauma, if there are no swelling, no tenderness, and a good range of motion of the joint, an X-ray is not clinically recommended. A comparative X-ray of the noninjured side is not recommended anymore as this was proven not to be of benefit in the vast majority of cases.[7,8] If comparison views are felt necessary, normal X-rays in various age groups are available on the net to compare. Another example is reducing the number of views requested for the injured part, e.g., an anteroposterior (AP) view is sufficient for a suspected neck femur fracture and for clinically obvious diaphyseal fractures of long bones with a clinically evident deformity that requires reduction under anesthesia or surgical fixation. As internal oblique view for the lateral humeral condyle in children is better in diagnosing and assessing the type and displacement,[9] requesting a single internal oblique view is better than requesting AP and lateral views of the elbow followed by the oblique view. During surgical procedures, radiation from the machines and the number of images could be reduced by ensuring and maintaining good communication with the X-ray technician during procedures.[10] The amount of radiation could be well reduced by using pulsed and low-dose mode fluoroscopy.[11] Pulsed fluoroscopy uses 1–6 images per second with much lower radiation exposure compared to continuous imaging, which uses 25–30 images per second.[12] The use of laser aiming guides, body part marking, and sticky tape on the floor to mark the C-arm position during surgery all help preventing off-center x-rays and thus reduce the number of images during surgery.[13] Using collimation to reduce the size of the aperture and voiding magnification both play a role in reducing the radiation dose.[11] The source of the radiation (the X-ray tube) should be kept as far from the patient as possible during the use of intraoperative C-arms.[14] These measures reduce the direct radiation to the patient and the scatter radiation to the staff. Patients' sensitive organs should be protected, especially when they are close to parts imaged. However, care should be taken to place protective shields properly, avoiding obliterating important areas to be viewed on the films, which would lead to repeated exposure. On follow-ups, a clinical judgment could replace unnecessary X-rays requests for many fractures; examples are fractures of the clavicle, metatarsals, metacarpals, and nondisplaced green-stick fractures.[15-17]

The other paper in the Journal's previous issue showed that the background knowledge and methods of reducing radiation during the use of C-arms in the operating room were indeed poor among doctors working in orthopedics. This clearly shows the importance of establishing mini-courses on radiation safety in the operating room.[18]

Among the measures that should be taken to minimize radiation exposure to staff and surgeons is shielding by using protective gear.[19] A lead-equivalent thickness of 0.5 mm attenuates over 95% of scattered X-rays that strike it.[20] Thyroid tissue is known to be susceptible to ionizing radiation and cancer; unfortunately, thyroid protection is frequently omitted by many orthopedic surgeons and staff during surgery.

Combining shielding with the reduction of exposure measures mentioned above results in a 97.3% reduction in effective dose to all operative room staff.[21]

Other important and effective simple measures include proper configuration of the C-arms with the tube away from the surgeon in the lateral view, which reduces the radiation to the surgeon 25-fold[22] and with the tube below the table in an AP view[23] and staying at the furthest distance possible. Combined with proper shielding, staying at the right distance reduces scattered radiation to 0.1% and 0.025% of the primary radiation at a distance of 3 and 6 feet, respectively.[24] With the X-ray tube below the table, dosimeters at a distance of 6 feet reported no radiation exposure.[13] Literature suggests that, at a distance

of 2 M or more away from the radiation source (tube for direct radiation and patient for scatter radiation), the amount of radiation is almost none, even without protective gear.[25]

Cumulative radiation measuring badges (dosimeters) are highly recommended to measure and monitor the radiation exposure of surgeons and staff.[26]

We should all take radiation exposure seriously and continue reminding colleagues of the importance of taking proper safety measures for the patients, staff, and ourselves while using C-arm machines in the operating room.

Financial support and sponsorship

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

There are no conflicts of interest.

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Received: 15-02-2021 **Revised:** 21-02-2021
Accepted: 22-02-2021 **Published Online:** 31-03-2021

Access this article online

Quick Response Code:

Website: www.journalmsr.com

DOI: 10.4103/jmsr.jmsr_17_21

How to cite this article: Kremli MK. Radiation: Are we and our patients protected enough?. J Musculoskelet Surg Res 2021;5:83-4.