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Utilizing the Laser Aiming of Image Intensifier Reduces the Exposed Radiation During Operation: A Prospective Analysis

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Mobile C-arm units provide real-time intraoperative imaging but expose both patients and staff to ionizing radiation. This study aims to reveal if the use of the laser targeting feature of image intensifiers (available in most of the latest series) is beneficial for preventing radiation exposure.
A randomized controlled trial was designed on the ankle fracture operations. Patients were randomly assigned to either the laser-targeting feature (LTF) group or the control group.
The study group has an average age of 40.8 years, ranging from 16 to 71; 23 were men and 27 women. The control group has an average age of 32.8 years, ranging from 16 to 78; 21 were women and 29 men. An average of 23 (20-30) fluoroscopy shots were taken during surgery in the study group. In contrast, an average of 38 (34-48) fluoroscopy shots were taken during surgery in the control group. The duration of surgery in the study group was 40 minutes (36-55 mins), whereas in the control group, it was 47 minutes (40-65 mins).
These findings suggest that integrated laser guidance may reduce radiation exposure during ankle fracture fixation surgery; however, multi-centre validation is warranted.

Keywords: Ankle fracture, radiation, exposure, fluoroscopy, trauma surgery.

INTRODUCTION

Orthopedic surgeons usually use mobile C-arm fluoroscopy unit during surgery. As the use of percutaneous and minimally invasive surgical methods increases, the need for mobile C-arm fluoroscopy units has started to increase.

These mobile C-arm fluoroscopy units are essential tools in modern orthopedic surgery, providing real-time imaging that helps surgeons perform precise interventions. The ability to obtain immediate feedback through fluoroscopy allows for more accurate placement of surgical instruments and implants, reducing the likelihood of complications and improving patient outcomes.

Although X-rays are helpful, they have potential hazards to living organisms and the environment[1,2]. They spread ionizing radiation, a well-known mutagen that can cause cancer. Diagnostic radiological imaging is essential for effective and efficient health care, but radiation exposures are cumulative and all radiation exposures are harmful[3]. The linear no-threshold model ideology for carcinogenicity suggests that there is no safe level of radiation exposure, and even the smallest doses can increase the risk of cancer[4].

The principle of ALARA (As Low As Reasonably Achievable) is a cornerstone in radiation safety, emphasizing the need to minimize exposure by all reasonable means[5]. Protective measures such as lead aprons, thyroid shields, and proper room design to maximize distance from the radiation source are essential practices in reducing occupational exposure for medical staff[6]. Moreover, advancements in technology, such as the development of digital radiography and improved image intensifiers, have contributed to lowering the required dose for effective imaging.

This study hypothesized that with LTF, orthopedic trauma surgeons would spend less time in the operating room with surgical procedures and have decreased fluoroscopy exposure. Utilization of LTF during surgical procedures would result in a diminished number of images taken per operation and a total mitigated radiation dose cumulant. The LTF not only aids in precise targeting but also reduces the need for multiple imaging attempts, thereby minimizing exposure to ionizing radiation[7].

Further understanding the implications of LTF in clinical practice is crucial. Studies have shown that accurate targeting with the help of laser technology can significantly enhance the precision of interventions, leading to better clinical outcomes and shorter operation times.

MATERIALS AND METHODS

Between January 29, 2021, and October 28, 2021, patients who presented to the emergency department with AO-OTA 44B1,44B2, 44C1 and 44C2 fractures were prospectively evaluated for the study. Cases with multiple fractures, open fractures and cases with soft tissue compromise were excluded. A total of 114 patients were evaluated. Initially, 3 patients refused surgical treatment. From the remaining 111 patients, 7 did not give consent to the study, and 4 abandoned the study in postoperative follow-up.

Ultimately, 100 patients with AO-OTA 44B2, 44B3, and 44C fractures who underwent surgery were included (Figure 1). Ethics Committee approval was obtained. Written informed consent was obtained from all participants prior to enrollment.

Patients were divided into two groups: the study group with LTF used during operation and the control group where LTF was not used. Randomization was performed using a sealed-envelope method. The allocation sequence was generated by an independent staff member who was not involved in patient recruitment or surgery. Opaque, sequentially numbered envelopes were prepared and stored in a locked location. For each participant, the operating room nurse opened the next envelope in sequence immediately before surgery, ensuring full allocation concealment. Neither the surgeons nor the patients were aware of the assignment prior to envelope opening.

All patients were operated on within one week after trauma (mean 2.3 days). All procedures were performed by the same surgical team. Anesthesia varied between spinal and general anesthesia. A pneumatic tourniquet was used in all surgeries. Fixation was performed through a standard lateral approach followed by medial malleolar reduction and fixation. A single syndesmosis screw was used in all cases.

Patients were positioned supine with 15-30 degrees of medial tilt on the operating table. The fluoroscopy device was present in the operating room from the beginning of the surgery. The first shot was taken after open reduction of the fibula fracture. In every case, fluoroscopic images were obtained after fibular reduction, after fixation in the anteroposterior view, and after syndesmosis screw placement in the lateral view (Figure 2). In the study group, shots were taken after using laser targeting. The surgical team pointed

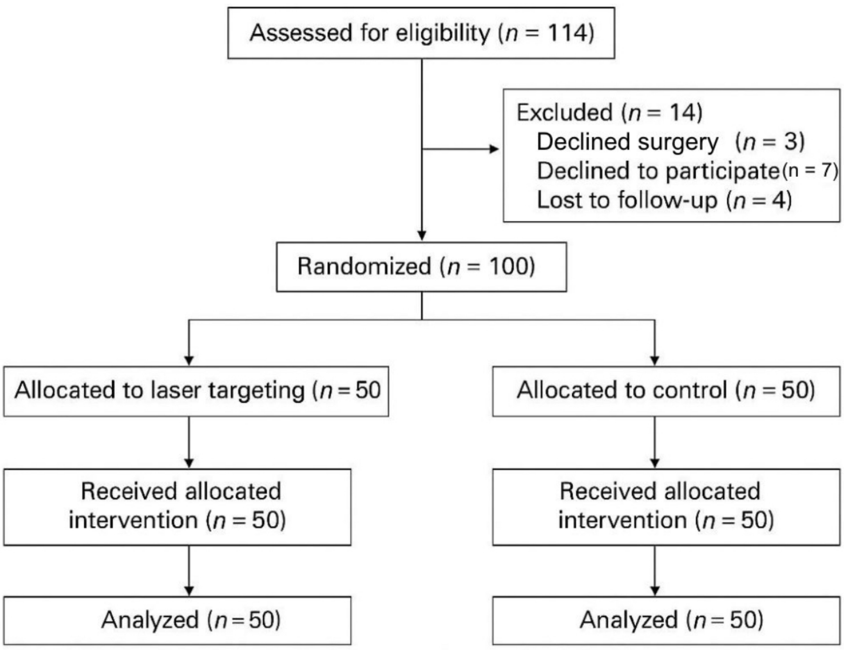

Fig. 1 — Study Design Diagram.

Fig. 2 — Laser Trait Pointing the Area.

to the spot and the radiology technician moved the image intensifier's laser target accordingly.

Dosimetry and Radiation Metrics:

Dose-area product (DAP) and fluoroscopy time were recorded directly from the mobile C-arm fluoroscopy unit's integrated dosimetry system for each procedure. These parameters were documented immediately after surgery and used as patient-related radiation output metrics. In addition, ambient operating-room exposure was assessed using fixed thermoluminescent dosimeters placed at standardized locations.

Spot radiation measurements inside the operating room were performed using calibrated thermoluminescent dosimeters (TLD-100, Harshaw, USA). All dosimeters underwent annual calibration in our institutional medical physics unit following IAEA TRS-398 protocols. Two dosimeters were placed for each case: one fixed at the level of the operative table and another fixed at a distance of 200 cm from the radiation source. Staff-worn personal dosimeters were positioned beneath lead aprons to measure deep-dose equivalent (Hp10). Background dose values were measured before each surgical session and subtracted during read-out. Dosimeter read-out was performed with a Harshaw 6600 TLD reader using a standardized annealing and read-out cycle.

Surgical timing was recorded for all subjects, starting from the incision to skin closure. The number of fluoroscopy shots was also recorded. Fluoroscopy time (in seconds and minutes) was automatically recorded by the mobile C-arm fluoroscopy unit for each procedure and documented as part of the radiation-exposure dataset. The device used was Genoray Zen-Genoray Am. Inc. Performance C-Arm - ZEN-7000. In the control group, the laser targeting feature was not used.

The statistical methods employed in this study were meticulously chosen to evaluate the findings and determine the differences between the groups.

Initially, descriptive statistics were calculated for demographic and baseline characteristics, with continuous variables presented as mean ± standard deviation and categorical variables expressed as frequencies and percentages. The independent samples t-test was used to compare means between the groups. Chi-square tests were employed to assess the relationships between categorical variables. To address any potential residual imbalance, secondary adjusted analyses were conducted using multivariable linear regression models with age and sex included as covariates. These analyses were performed to confirm the robustness of the primary results. A two-sided p value < 0.05 was considered statistically significant. Statistical analyses were performed using SPSS version 25.0.

RESULTS

Baseline demographic and clinical characteristics were comparable between the study and control groups, with no statistically significant imbalance detected in age, sex, BMI, fracture pattern, laterality, or syndesmotic involvement. In the study group the average age of patients was 38.4 years, with a range from 16 to 71 years. There were 23 men and 27 women in this group. However in the control group, the average age of patients was 31.5 years, with a range from 16 to 78 years. This group included 21 women and 29 men (Table I).

In the study group, an average of 23 fluoroscopy shots were taken per surgery, with a range from 20 to 30 shots. On the other hand, in the control group, an average of 38 fluoroscopy shots were taken per surgery, with a range from 34 to 48 shots.

The difference in the number of fluoroscopy shots between the two groups was statistically significant ($p < 0.05$), indicating that the use of LTF substantially reduced the number of shots required.

In this study, a comparison of surgical durations between two groups was also conducted. In the study group, the average duration of surgery was found to be 40 minutes, with a range spanning from 36 to 55 minutes. In contrast, the control group had an average surgical duration of 47 minutes, with a broader range between 40 and 65 minutes.

These findings indicate that the surgery duration in the study group was shorter compared to the control group. Additionally, the distribution of surgical times between the two groups differs; the study group exhibited a narrower range (36-55 minutes), while the control group demonstrated a wider range (40-65 minutes) (Table II). This suggests that the surgical duration in the study group was more predictable and consistent, whereas in the control group, it was more variable. These results imply that the protocol implemented in the study group may be more effective in optimizing surgical durations compared to the control group. Moreover, the reduction in surgery time with the use of LTF was also statistically significant ($p < 0.05$).

To consider radiation exposure, it is noteworthy that in the study group the mean calculated dosimeter value was 0.69 mGy. On the other hand, in the control group, the mean dosimeter value was 1.12 mGy. DAP and fluoroscopy time were successfully obtained for all 100 procedures. The laser-targeting group showed markedly lower radiation output compared with the control group, consistent with the reduction in fluoroscopy shots. Mean DAP and mean fluoroscopy time values for both groups are presented in Table III. Fluoroscopy time was significantly lower in the LTF group compared with the control group. The mean fluoroscopy time was 32.88 ± 4.59 seconds (range:

Table I. — Demographic Data.

Variable	Study Group (n=50)	Control Group (n=50)	p-value*
Age (mean ± SD)	40.8 ± 11.5	32.8 ± 9.6	>0.05
Sex, n (%)			>0.05
Male	23 (46%)	29 (58%)	
Female	27 (54%)	21 (42%)	
Fracture Pattern, n (%)			>0.05
AO-OTA 44B2	16	21	
AO-OTA 44B3	17	20	
AO-OTA 44C	17	9	
Side, n (%)			>0.05
Right	22	25	
Left	28	25	
BMI (mean ± SD)	26.6 ± 3.0	25.7 ± 2.8	>0.05
Presence of Syndesmotic Injury, n (%)	11 (22%)	11 (22%)	>0.05

Table II. — Fluoroscopy Shots and Surgery Duration Table.

Group	Average Fluoroscopy Shots	Fluoroscopy Shot Range	Average Surgery Duration (mins)	Surgery Duration Range (mins)
Study Group	23	20-30	40	36-55
Control Group	38	34-48	47	40-65

Table III. — Radiation Parametrics.

Radiation Parameter	Laser-Targeting Group (n = 50)	Control Group (n = 50)	p-value*
Fluoroscopy shots (n)	24.66 ± 3.45 (20 – 30)	40.80 ± 4.37 (34 – 48)	<0.005
DAP (mGy·cm²)	108.10 ± 15.11 (87.7 – 131.5)	178.84 ± 19.14 (149.0 – 210.4)	<0.001
Fluoroscopy time (seconds)	32.88 ± 4.59 (26.7 – 40.0)	54.39 ± 5.82 (45.3 – 64.0)	<0.005
Ambient room radiation dose (mGy)	0.69	1.12	—

26.7–40.0) in the LTF group and 54.39 ± 5.82 seconds (range: 45.3–64.0) in the control group ($p < 0.005$).

The reduction in radiation exposure for the study group compared to the control group was statistically significant ($p < 0.05$). This demonstrates that using LTF not only reduces the number of fluoroscopy shots but also significantly lowers the total radiation dose.

Analysis of dosimeter readings showed a significant decrease in radiation levels at a distance of 200 cm from the operating table, indicating effective dispersion and reduction of radiation with increased distance. This aligns with the principles of radiation safety emphasizing time, distance, and shielding.

The study's statistical power was calculated to be 0.85, indicating a high probability that the study correctly rejected the null hypothesis (i.e., there is a true effect of using LTF in reducing fluoroscopy shots and radiation exposure). These approaches provide a scientific foundation to enhance the reliability and validity of the study's outcomes.

DISCUSSION

The primary objective of this study was to evaluate the efficacy of the Laser Targeting Feature (LTF) in reducing radiation exposure during orthopedic surgeries, particularly in operations involving ankle fractures. This study demonstrated that the implementation of LTF significantly decreased the number of fluoroscopy shots required during surgery, thereby reducing the radiation dose received by both the surgical team and patients. These findings are consistent with the principles of radiation safety and support the broader goal of minimizing exposure to ionizing radiation wherever possible.

Our findings align with recent advancements in surgical imaging technologies aimed at improving safety and efficacy. Integration of advanced imaging systems in orthopedic surgery and found that such systems significantly enhanced the precision of surgical interventions while reducing radiation exposure. Similarly, the introduction of navigation systems in orthopedic trauma surgery has been shown to decrease the need for fluoroscopic imaging, thereby minimizing radiation exposure to both the patient and the surgical team[7,8]. These studies corroborate our findings, underscoring the value of incorporating technologies like LTF to enhance safety in the operating room.

One of the critical findings of our study is the substantial reduction in the number of fluoroscopy shots required during surgeries where LTF was utilized. On average, the study group, which employed LTF, required 23 fluoroscopy shots per surgery, compared to 38 shots in the control group. This difference is not only statistically significant but also clinically relevant, as it translates into a considerable reduction in radiation exposure. The reduced radiation dose is particularly important which emphasized the cumulative risks associated with repeated exposure to ionizing radiation in medical settings[9]. Literature highlighted that even low-dose exposures, when accumulated over time, could contribute to an increased risk of malignancies, reinforcing the importance of minimizing unnecessary radiation[10].

Moreover, the shorter surgical duration observed in the LTF group—averaging 40 minutes compared to 47 minutes in the control group—further supports the efficacy of LTF. This reduction in surgical time not only reflects improved operational efficiency but also contributes to better patient outcomes by reducing the overall time under anesthesia, as supported by recent literature[11]. For example, the study by Cheng et al. demonstrated that shorter operative times in orthopedic surgeries were associated with reduced postoperative complications and faster recovery times, a finding that echoes the benefits observed in our study with the use of LTF[12].

When comparing our findings to previous research, it is evident that the integration of advanced imaging technologies in surgical procedures has been a focal point in recent orthopedic research. A previously published systematic review highlighted the growing body of evidence supporting the use of image-guided systems to enhance surgical precision while concurrently reducing radiation exposure[8]. Their review included multiple studies demonstrating that technologies like LTF and intraoperative navigation systems not only improve surgical accuracy but also reduce the need for repeated fluoroscopic imaging, leading to lower radiation doses. This aligns with the significant reduction in radiation exposure observed in our study, where the LTF group exhibited a mean dosimeter value of 0.69 mGy, significantly lower than the 1.12 mGy observed in the control group.

Despite the promising outcomes, this study has certain limitations that must be acknowledged. One primary limitation is the relatively small sample size, which, although sufficient to demonstrate significant differences between the study and control groups, limits the generalizability of the findings. Additionally, our study focused exclusively on ankle fractures, a narrow subset of orthopedic conditions. Future research should consider expanding the scope of study to include a broader range of fracture types and surgical procedures, which would provide a more comprehensive understanding of the benefits and limitations of LTF. Recent studies have shown that the effectiveness of imaging technologies can vary significantly depending on the type of surgery and patient demographics, suggesting that further research is needed to fully explore the potential of LTF in diverse clinical settings[13].

Another potential limitation is the lack of evaluation of the distribution of fracture types between the two groups. Although the study was designed to control for variables such as age and gender, the specific types of fractures were not systematically compared between the groups. While this is not expected to significantly affect the outcomes due to the study's narrow focus on specific fracture subtypes, it remains a factor that could be explored in future research. A recent study emphasized the importance of considering fracture type and complexity when evaluating the effectiveness of imaging technologies, as these factors can significantly influence both the number of fluoroscopy shots required and the overall radiation dose[14].

Previous studies evaluating laser-guided fluoroscopy have reported mixed results, largely due to small sample sizes, heterogeneous fracture types, and the use of externally mounted laser devices. In contrast, the present study examines a built-in laser targeting system integrated directly into the mobile C-arm fluoroscopy unit, which eliminates alignment variability associated with detachable accessories. Moreover, ankle fractures represent a clinical scenario in which fluoroscopy demand is particularly high, making radiation reduction strategies especially relevant. These methodological differences may explain the clearer reduction in radiation metrics observed in our cohort. Nevertheless, although the findings are promising, further multi-centre studies involving different surgical teams and institutional workflows are needed to validate the generalizability of our results.

The study's strengths, however, are noteworthy. The rigorous methodology, including the use of a randomized controlled trial design and careful statistical analysis, provides a robust foundation for the study's conclusions. The significant reduction in both the number of fluoroscopy shots and surgical duration in the LTF group suggests that the implementation of LTF can enhance the efficiency and safety of orthopedic surgeries. The use of dosimeters to measure radiation exposure further strengthens the study by providing objective, quantifiable data on the reduction in radiation dose achieved through the use of LTF. This methodological rigor aligns with the standards outlined by recent reviews on best practices in clinical trials for surgical technologies.

In conclusion, our study clearly demonstrates that the use of LTF in the mobile C-arm fluoroscopy units during orthopedic surgeries significantly reduces the number of fluoroscopy shots required, thereby minimizing radiation exposure for both patients and surgical staff. These findings have important implications for clinical practice, as they suggest that the adoption of LTF can enhance the safety and efficiency of surgical procedures. The results also align with the broader goals of radiation safety and the ALARA (As Low As Reasonably Achievable) principle, which advocates for minimizing radiation exposure by all reasonable means. Future research should continue to explore the benefits of LTF in a wider range of clinical settings and surgical procedures, potentially expanding sample sizes and including more diverse patient populations to enhance the generalizability of these findings[5]. Additionally, multicenter studies could offer valuable insights into the variability of LTF's effectiveness across different healthcare environments, as suggested by recent meta-analyses in the field[15].

In summary, the integrated laser-targeting feature demonstrated a meaningful reduction in fluoroscopy use, dose-area product, and fluoroscopy time during ankle fracture fixation. These findings suggest that built-in laser guidance may enhance intraoperative efficiency while contributing to radiation-safety efforts[16,17]. However, the present results should be interpreted within the context of a single-centre study with a standardized surgical team. Broader multi-centre investigations involving diverse practice environments are required to validate the generalizability of these outcomes and to determine the full clinical applicability of this technology.

REFERENCES

1. Nüsslin F. Wilhelm Conrad Röntgen: The scientist and his discovery. Phys Med. 2020 Nov;79:65-68. doi: 10.1016/j.ejmp.2020.10.010. Epub 2020 Nov 3. PMID: 33157455.
2. Balter S. X-ray image intensifier. Catheter Cardiovasc Interv. 1999 Feb;46(2):238-44. doi: 10.1002/(SICI)1522-726X(199902)46:2<238::AID-CCD26>3.0.CO;2-Y. PMID: 10348552.
3. Shelly E, Waldron MG, Field E, Moore N, Young R, Scally A, et al. Cumulative Radiation Dose from Medical Imaging in Children with Congenital Heart Disease: A Systematic Review. Children [Internet]. 2023 Apr 1 [cited 2024 Oct 9];10(4):645. Available from: https://www.mdpi.com/2227-9067/10/4/645/htm
4. UNSCEAR. Effects of Ionizing Radiation. UNSCEAR Report to the General Assembly With Scientific Annexes. New York NY: UNSCEAR; 2020/2021.
5. Wali AR, Sindewald RW, Brandel MG, Pathuri S, Hirshman BR, Bravo JA, Steinberg JA, Pannell JS, Khalessi A, Santiago-Dieppa DR. ALARA principles in practice: reduced frame and pulse rates for middle meningeal artery embolization. J Cerebrovasc Endovasc Neurosurg. 2024 Sep;26(3):293-297. doi: 10.7461/jcen.2024.E2024.02.003. Epub 2024 Aug 5. PMID: 39091261; PMCID: PMC11449538.
6. Devalia KL, Guha A, Devadoss VG. The need to protect the thyroid gland during image intensifier use in orthopaedic procedures. Acta Orthop Belg. 2004 Oct;70(5):474-7. PMID: 15587037.
7. Dagnino G, Georgilas I, Morad S, Gibbons P, Tarassoli P, Atkins R, Dogramadzi S. Intra-operative fiducial-based CT/fluoroscope image registration framework for image-guided robot-assisted joint fracture surgery. Int J Comput Assist Radiol Surg. 2017 Aug;12(8):1383-1397. doi: 10.1007/s11548-017-1602-9. Epub 2017 May 4. PMID: 28474269; PMCID: PMC5541125.
8. Fan X, Zhu Q, Tu P, Joskowicz L, Chen X. A review of advances in image-guided orthopedic surgery. Phys Med Biol. 2023 Jan 5;68(2). doi: 10.1088/1361-6560/acaae9. PMID: 36595258.
9. Mathews J D, Forsythe A V, Brady Z, Butler M W, Goergen S K, Byrnes G B et al. Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians BMJ 2013; 346 :f2360 doi:10.1136/bmj.f2360
10. Vaiserman A, Koliada A, Zabuga O, Socol Y. Health Impacts of Low-Dose Ionizing Radiation: Current Scientific Debates and Regulatory Issues. Dose Response. 2018 Sep 19;16(3):1559325818796331. doi: 10.1177/1559325818796331. PMID: 30263019; PMCID: PMC6149023.
11. Bohl DD, Ondeck NT, Darrith B, Hannon CP, Fillingham YA, Della Valle CJ. Impact of Operative Time on Adverse Events Following Primary Total Joint Arthroplasty. J Arthroplasty. 2018 Jul;33(7):2256-2262.e4. doi: 10.1016/j.arth.2018.02.037. Epub 2018 Feb 17. PMID: 29551302.
12. Cheng H, Clymer JW, Po-Han Chen B, Sadeghirad PhD B, Ferko NC, Cameron CG, et al. Prolonged operative duration is associated with complications: a systematic review and meta-analysis. Journal of Surgical Research. 2018 Sep 1;229:134–44.
13. Hurley RJ, McCabe FJ, Turley L, Maguire D, Lucey J, Hurson CJ. Whole-body radiation exposure in Trauma and Orthopaedic surgery. Bone Jt Open. 2022 Nov;3(11):907-912. doi: 10.1302/2633-1462.311.BJO-2022-0062.R1. PMID: 36416077; PMCID: PMC9709492.
14. Fabião L, Ribau A, Lemos C, Rodrigues-Pinto R. Intraoperative fluoroscopic radiation in orthopedic trauma: correlation with surgery type and surgeon experience. Porto Biomed J. 2023 Jun 23;8(3):e218. doi: 10.1097/j.pbj.0000000000000218. PMID: 37362016; PMCID: PMC10289723.
15. Chodick G, Bekiroglu N, Hauptmann M, Alexander BH, Freedman DM, Doody MM, Cheung LC, Simon SL, Weinstock RM, Bouville A, Sigurdson AJ. Risk of cataract after exposure to low doses of ionizing radiation: a 20-year prospective cohort study among US radiologic technologists. Am J Epidemiol. 2008 Sep 15;168(6):620-31. doi: 10.1093/aje/kwn171. Epub 2008 Jul 29. PMID: 18664497; PMCID: PMC2727195.
16. López PO, Dauer LT, Loose R, Martin CJ, Miller DL, Vañó E, Doruff M, Padovani R, Massera G, Yoder C; Authors on Behalf of ICRP. ICRP Publication 139: Occupational Radiological Protection in Interventional Procedures. Ann ICRP. 2018 Mar;47(2):1-118. doi: 10.1177/0146645317750356. Erratum in: Ann ICRP. 2019 Sep;48(1):99. doi: 10.1177/0146645318773608. Erratum in: Ann ICRP. 2019 Sep;48(1):98. doi: 10.1177/0146645319860189. PMID: 29532669.
17. Raffetto ML, Blum LE, Abbenhaus EJ, Hautala GS, Lemieux B, Pease T, Wright RD, Moghadamian ES, Aneja A, Blair JA, Matuszewski PE. Radiation Exposure Among Orthopaedic Trauma Surgeons: Deconstructing Commonly Held Myths and Misperceptions. J Orthop Trauma. 2022 Aug 1;36(8):375. doi: 10.1097/BOT.0000000000002340. PMID: 34992194.