Radiation safety education as a component of orthopedic training

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Abstract

Fluoroscopy poses an occupational hazard to orthopedic surgeons. The purpose of this study was to examine resident and faculty understanding of radiation safety and to determine whether or not a radiation safety intervention would improve radiation safety knowledge. An anonymous survey was developed to assess attitudes and knowledge regarding radiation safety and exposure. It was distributed to faculty and residents at an academic orthopedic program before and after a radiation safety lecture. Pre- and post-lecture survey results were compared. 19 residents and 22 faculty members completed the pre-lecture survey while 11 residents and 17 faculty members completed the post-lecture survey. Pre-lecture survey scores were 48.3% for residents and 49.5% for faculty; post-lecture survey scores were 52.7% and 46.1% respectively. Differences between pre and post-survey scores were not significant. This study revealed low baseline radiation safety knowledge scores for both orthopedic residents and faculty. As evidence by our results, a single radiation safety information lecture did not significantly impact radiation knowledge. Radiation safety training should have a formal role in orthopedic surgery academic curricula.

Introduction

Ionizing radiation is a ubiquitous tool used to diagnose and treat patients across orthopedic subspecialties. In recent decades, the increased use of fluoroscopy by way of c-arm and mini-c-arm has aided the treatment of patients in the operating room, emergency department, and outpatients setting. The use of ionizing radiation poses an occupational hazard to orthopedic surgeons.1

The risk posed by an occupational hazard is related to the degree and duration of exposure to the hazard. It is known that radiation exposure increases the risk of cancer (e.g. thyroid) and cumulative exposure increases the risk of cataracts.2,3 The United States Nuclear Regulatory Commission (NRC) offers strict dose limitations for workers exposed to radiation. These yearly limits include a 50,000 millirem (mrem) dose limit to the skin and extremities, a 15,000 mrem limit to the lens of the eye, and total body dose equivalent limit of 5,000 mrem.4 To protect healthcare workers from the deleterious effects of radiation exposure, the U.S. Occupational Safety and Health Administration (OSHA) requires hospitals to provide employees with radiation safety training and protective equipment.5

A dedicated body of research exists regarding radiation exposure in the field of orthopedic surgery.5-11 Several factors that influence exposure risk have been identified including type of surgery, distance from radiation source, subspecialty practiced, and experience level of the surgeon.1,5,8-11 Several precautions can be taken to limit radiation exposure including the principles of maximizing distance from the radiation source, limiting time of exposure, avoiding direct exposure of body parts, and the use of protective equipment including lead aprons, thyroid shields, and glasses (Table 1).3 What is less well known is how much orthopedic surgeons know about the risks of radiation exposure and whether/how often they apply the principles of exposure prevention. More recently, studies examined the attitudes and practices of surgeons, trainees, and healthcare workers regarding ionizing radiation. While exposure totals do not seem to approach yearly limits set by the NRC, understanding of dose limitations, risks of exposure, and personal prophylactic practices is suboptimal.10,14-17 For instance, a recent study by Bowman and colleagues surveyed orthopaedic residents on radiation safety training, provision of personal protective equipment, and general radiation knowledge. Results indicated low baseline radiation knowledge scores: 39% of residents knew the recommended distance to stand from a radiation source, 10.8% knew yearly allowable radiation dose limitations, and only 32.4% were aware of the American Academy of Orthopaedic Surgery (AAOS) guidelines regarding the use of personal protective equipment. Lack of knowledge of AAOS guidelines was associated with poor personal protective equipment compliance.18

Limited use of protective radiation equipment is concerning, considering radiation is an occupational hazard faced daily by orthopedic surgeons. It remains unclear what combination of education and availability of protective equipment may improve understanding and safety compliance and decrease yearly exposure. The purpose of this study was to examine resident and faculty understanding and attitudes regarding radiation safety in an effort to improve radiation safety training as part of our academic curriculum. We hypothesized that baseline knowledge would be similar to prior studies and that a single radiation safety information session would not significantly impact resident or faculty radiation safety knowledge.

Materials and Methods

A 17-question survey was created by the authors to assess orthopedic resident and faculty knowledge and practices regarding radiation safety. The survey consisted of 10 questions addressing radiation and safety and 7 questions related to demographics and self-assessment of radiation understanding and safety practices. The survey was anonymous and voluntary and no identifying information was collected. After IRB approval at the primary author’s institution, the survey was distributed to both residents and faculty members via an online platform to obtain a baseline score. One week following survey distribution, an

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educational lecture on radiation safety was given at Orthopaedic Surgery Grand Rounds. This was attended by all resident and faculty members participating in the study. Within 2 weeks of the lecture, the initial survey was redistributed to resident and faculty members. Survey results were analyzed and statistical analysis was performed using Microsoft Excel, a P-value of 0.05 was set as statistically significant. The primary outcome measure was pre- and post-test performance.

**Results**

A total of 19 residents and 22 faculty members completed the initial pre-lecture survey. The post-lecture survey was then completed by 11 residents and 17 faculty members. Resident responses by post-graduate year (PGY) and faculty responses by years in practice are represented in Figures 1 and 2 respectively. On a scale of 1-5, residents self-rated their radiation safety knowledge level as 2.8 (range 1-4) on their pre-lecture survey compared to an average of 3.1 (2-5) on the post lecture survey, P=0.4 (Table 2). Faculty members self-rated an average radiation safety knowledge level of 3.5 (1-4) on the pre-lecture survey, which decreased to an average of 3.2 (1-4) on the post-lecture survey (Table 2). Self-rated faculty member radiation safety knowledge was significantly higher than resident self-rated knowledge 3.5 vs. 2.8 (P<0.01). Residents averaged a pre-lecture score of 48.3% on their knowledge questions compared to a post lecture average score of 52.7% (P>0.4). Faculty members scored an average of 49.5% on their pre-lecture knowledge questions compared to 46.1% on their post-lecture survey (P<0.4). There was no statistically significant difference between the residents and faculty members’ results (Table 2). Overall, 70% of residents and 80% of faculty members felt that the radiation safety lecture was a valuable addition to the educational curriculum, however, neither group demonstrated statistical improvement in their scores after the lecture.

**Discussion**

This study demonstrated that faculty self-rated radiation safety knowledge scores were significantly higher than resident scores. Resident scores on knowledge-based questions improved pre-test to post-test (48.3% to 52.7%), while faculty scores declined (49.5% to 46.1%), although neither change was statistically significant. These results support prior findings suggesting there is a need for improvement in radiation safety training and exposure prevention for orthopedic practitioners.

Previous studies demonstrated that radiation experienced by orthopedic surgeons falls below yearly limits established by the NRC. However, no dose of radiation exposure is without the risk of potential adverse effects. It remains unknown what combination of education and access to personal protective equipment will further

**Figure 1. Number of resident pre and post-lecture survey responses by post-graduate year (PGY).**

**Figure 2. Number of faculty pre and post-lecture survey responses by number of years in practice.**

**Table 1. Safety principles to reduce radiation exposure.**

| Use of personal protective equipment          | Modifiable risk factors                  |
|-----------------------------------------------|------------------------------------------|
| Lead apron                                    | Maximize distance from source            |
| Thyroid shield                                | Minimize time of exposure                |
| Appropriate dosimeter use                     | Avoid direct exposure to limbs           |
| Lead glasses                                  | Avoid scatter                            |

**Table 2. Resident and faculty self-rated knowledge scores (rated 1-5) pre-lecture and post-lecture as well as resident and faculty radiation knowledge scores (%) pre-lecture and post-lecture.**

|                              | Pre-lecture survey | Post-lecture survey |
|------------------------------|--------------------|---------------------|
| Resident self-rated knowledge level (1-5) | 2.8                | 3.1                 |
| Faculty self-rated knowledge level (1-5)   | 3.5                | 3.2                 |
| Resident quiz score (%)          | 48.30              | 52.70               |
| Faculty quiz score (%)           | 49.50              | 46.10               |
Education about radiation safety has been shown to reduce the radiation exposure to orthopedic surgeons. In 2016, Gendelberg et al. examined radiation exposure of patients and residents using mini C-arm fluoroscopy for fracture reduction before and after an education intervention. The intervention consisted of a 2-hour radiation safety lecture followed by a 1-hour reduction practice session using Geiger counters to provide real-time feedback of the effectiveness of radiation safety measures. Fluoroscopy exposure time and radiation dose were calculated for reduction of pediatric both bone forearm and distal radius fractures in the 3 months before and after the educational intervention. Pre-intervention, the average fluoroscopy exposure time for both bone forearm and distal radius fractures were 41.2 seconds and 28.1 seconds respectively. Post-intervention exposure times were 28.9 and 26.7 seconds respectfully. Average pre-intervention radiation dosage for both bone forearm and distal radius fractures were 90.9 millirem (mRem) and 83.1 mRem respectively. Average post-intervention radiation dosages were 30.4 mRem and 32.6 mRem respectively. The radiation education program was shown to significantly reduce fluoroscopy time and radiation experienced by patients and residents during pediatric fracture reductions. Gendelberg and colleagues also showed that benefits of the radiation safety intervention were sustained. One year post-intervention, radiation exposure time and dosage remained lower compared to pre-intervention. These results indicate that a radiation safety training program can reduce radiation exposure experienced by practitioners. This study has several limitations. It was conducted at one academic orthopedic training program and thus our sample size is small. Therefore, the results cannot necessarily be generalized to all orthopedic residency programs. Pre-test and post-test responses were completed on a volunteer basis to maintain anonymity. Only 58% of residents who voluntarily completed the pre-test survey also completed the post-test survey, while 77% of faculty completing the pre-test survey also completed the post-test survey. Surveys were anonymous and thus responses were completed on a volunteer basis to maintain anonymity. Only 58% of residents who voluntarily completed the pre-test survey also completed the post-test survey, while 77% of faculty completing the pre-test survey also completed the post-test survey. Surveys were anonymous and thus we were unable to assess whether post-test respondents also completed the pre-test. Since both questionnaires were completed voluntarily there is a selection bias potentially towards respondents interested in radiation safety. There were also fewer responses to the post-test compared to pre-test in both faculty and resident groups further decreasing the sample size.

Conclusions

This study shows similar radiation knowledge between faculty and residents at one academic orthopedic training program. Self-reported radiation knowledge was high considering actual knowledge scores were about 50% for both faculty and residents. The single education intervention did not affect radiation knowledge scores. Current radiation safety education in orthopedic surgery training programs is insufficient. Radiation safety training should have a formal role in orthopedic training curricula and needs to include more than one lecture to provide sufficient education, although the ideal educational program has not yet been defined.

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