

Surgeons' Perception of Fluoroscopic Radiation Hazards to Vision

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Abstract

Exposure to ionizing radiation, such as that used in fluoroscopy, can lead to cataracts. This is relevant in orthopedic surgery as fluoroscopic procedures are commonly performed.

In this study, we determined perceived level of: (1) personal risk, (2) awareness of risk for cataract formation due to ionizing radiation exposure, (3) awareness of occupational dose limits for ophthalmologic radiation exposure, (4) current radioprotective practices amongst orthopedic surgeons. Canadian Orthopaedic Association members were asked to participate and 264 responses (23%) were received.

Many respondents believed that they were at least at moderate risk for cataract formation due to occupational radiation exposure ($n = 107$; 41%). Fifty-nine respondents (22%) indicated that they lacked sufficient knowledge to estimate risk and almost half ($n = 120$; 45%) reported having minimal awareness that ionizing radiation may contribute to cataractogenesis; almost 75% ($n = 197$) reported having minimal awareness that dose limits exist. The association between perceived risk and awareness was significant ($P < .001$).

There is an information deficit among orthopedic surgeons regarding awareness of either the potential cataractogenesis risk due to radiation exposure or the dose limits.

Ionizing radiation, such as that used in fluoroscopy, conventional radiography, and computed tomography, in high doses, can lead to cataract development.¹⁻⁴ This has been established in studies of World War II atomic bomb survivors,¹⁻⁴ early cyclotron workers,^{5,6} and persons who have received head and neck or total body irradiation as medical treatments.⁷⁻⁹ Initial analyses reported that the risk of catarac-

togenesis from radiation exposure appeared deterministic, meaning that a threshold dose must be exceeded before there is risk of injury and that a dose-response relationship exists above this threshold. More recently, the level of the threshold dose, and even the deterministic effect of radiation on the lens, has been challenged by studies¹⁰⁻¹² on chronic low-level radiation exposure.¹³⁻²³ As a result of this accumulating data, the International Commission on Radiological Protection (ICRP) recommendations stated that the Commission would be re-evaluating their recommendations for ocular exposure.^{24,25} The current allowable annual dose limit for the eyes is 150 milliSievert (mSv), but the ICRP suggests that there should be particular optimization of ocular exposure risks until this level has been proven not to lead to ocular damage.²⁵

The use of ionization radiation is pervasive throughout the field of orthopedic surgery, and surgeon exposure is largely unavoidable. Documented exposure levels to the head and neck including the eyes, are low,²⁶⁻³¹ and data evaluating the risk to orthopedic surgeons are lacking. While interventional radiologists routinely use radioprotective glasses during fluoroscopic procedures, their use among orthopedic surgeons and residents is uncommon. In addition, no formal education process exists to inform exposed individuals about potential risks and possible radioprotective strategies. A recent review article found that surgeons appear largely unaware of their occupational hazards.³² Therefore, orthopedic surgeons and residents are conceivably at increased risk of cataractogenesis without being able to make an informed decision about radioprotective eyewear use.

The purpose of this study was to determine the following among orthopedic surgeons and residents in Canada:

- (1) The perceived level of personal risk for cataract formation from ionizing radiation exposure accumulated over the course of their careers,
- (2) The awareness level of the risk of cataract formation due to ionizing radiation exposure,
- (3) The awareness level of the existence of ICRP and NCRP dose limits for the amount of radiation exposure to the eyes in an occupational setting, and
- (4) The current radioprotective practices, including radioprotective eyewear use.

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We hypothesized that orthopedic surgeons and residents would perceive themselves to be at low risk for cataract formation, that awareness of both the risk of cataractogenesis and the existence of occupational exposure limits would be limited, and that radioprotective eyewear would be infrequently worn.

Materials and Methods

A descriptive e-mail survey was sent to all members of the Canadian Orthopaedic Association (COA) in 2010, including active and retired orthopedic surgeons, and orthopedic surgery residents and fellows. Because a population-based sampling approach was utilized, no sample size calculations were performed.³³ Ethics approval was obtained from the University of Alberta Health Research Ethics Board.

To develop the survey and create a panel, we reviewed the literature³⁴ pertaining to the risk of cataractogenesis due to occupational radiation exposures and the prevalence of cataracts in occupationally exposed persons as well as literature examining the perception and/or the awareness of cataract risk amongst occupationally exposed persons. No articles

were found specific to orthopedic surgery. We then formulated an expert panel of 2 orthopedic surgeons, an ophthalmologist, orthopedic research staff, a senior orthopedic surgery resident, and a radiation technologist to undertake item generation, format and edit the questionnaire in an iterative fashion to increase question clarity.³⁵ Responses were primarily close-ended to increase completion rates and for ease of data interpretation.^{35,36}

The draft questionnaire was pilot-tested with orthopedic surgeons and residents in Edmonton, Alberta to further assess survey clarity and validity.³⁵ The final questionnaire contained the following domains: (1) perception of risk, (2) awareness of risk, (3) use of fluoroscopy, (4) use of protective equipment and strategies, and (5) demographics.

The survey was developed into a web-based application, and invitations to participate were distributed via e-mail using a COA membership list. Two reminder e-mails were also sent at weekly intervals for a total data collection window of approximately 4 weeks. Data collection was performed by an independent third party in the Academic Information and Communication Technologies department at the University of Alberta. No investigators were involved in data collection, and all data forwarded to the investigators were anonymous.

Descriptive analyses were performed for all responses, including frequencies, proportions, means, and standard deviations (SD). Estimated weekly radiation exposure was calculated as the product of each respondent's estimated number of procedures performed per week and the estimated average use of fluoroscopy (in seconds) per procedure. Categories were arbitrarily set at low (≤ 300 s/week), moderate (301-599 s/week), and high exposure levels (≥ 600 s/week). These estimates were not validated as a surgeon's personal estimated use of fluoroscopy, but was considered to be more relevant to their perceived cataract risk than their actual amount of fluoroscopy use.

Associations between perception of risk and awareness were examined using chi square tests. The effect of a surgeon's estimated use of fluoroscopy on their perceived risk of cataractogenesis was also explored. All analyses were performed using Predictive Analytics Software (PASW) version 18.0 (SPSS Inc, Chicago, Illinois).

Results

Demographics

Two hundred and sixty-four responses (23%) were received from a total of 1132 distributed questionnaires. Demographics, including age, career stage, duration in orthopedic practice, and subspecialty practice(s) are listed in **Table I**.

Perception of Risk

Almost half of the respondents believed that they were at either moderate ($n = 107$; 41%) or extreme risk ($n = 20$; 8%) for cataract formation due to accumulated occupational radiation exposures. Less than 30% of respondents believed that they were either at no risk ($n = 6$; 2%) or only minimal risk ($n = 72$; 27%). Twenty-two percent ($n = 59$) of respondents

Table I. Demographics of Respondents (n = 264)

Characteristics	Total
Age, years (%)	
<31	27 (10)
31-40	96 (36)
41-50	58 (22)
51-60	42 (16)
>60	41 (16)
Stage of Career, n (%)	
Resident/Fellow	60 (23)
Active Practice	191 (72)
Retired	13 (5)
Duration of Orthopedic Practice, years (%)	
<5	48 (18)
5-10	60 (23)
11-20	63 (24)
31-30	49 (18)
>30	44 (17)
Area(s) of Practice, n (%)*	
Trauma	108 (41)
Arthroplasty	104 (39)
General Practice	91 (34)
Sports	77 (29)
Upper Extremity	65 (25)
Foot and Ankle	45 (17)
Pediatrics	42 (16)
Spine	36 (14)
Tumor	9 (3)

*Able to select all that apply; % does not equal 100%

indicated that they did not have sufficient knowledge to estimate their risk.

Awareness of Risk and ICRP Limits

Forty-five percent ($n = 120$) of the respondents reported having no or minimal awareness that ionizing radiation may contribute to cataractogenesis, while 74% ($n = 197$) of the respondents reported having no or minimal awareness that ICRP annual dose limits exist (Figure 1). In addition, approximately 60% ($n = 158$) of the respondents recorded that their radiation exposure in comparison to the ICRP limit was “unknown” as they were unaware of the existence of dose limits. Twenty-six percent ($n = 68$) of respondents still estimated that they were likely or definitely under the limit, while 14% ($n = 8$) indicated that they were likely equal to or over the limit.

Estimated Use of Fluoroscopy

More than half of the respondents ($n = 147$; 56%) were categorized as using low amounts of fluoroscopy (≤ 300 s/week), 78 respondents (30%) as using moderate amounts (301 to 599 seconds/week), and 39 respondents (15%) as using high amounts (≥ 600 s/week).

Current Use of Radioprotective Eyewear

Ninety-one percent ($n = 234$) of respondents indicated that they never use radioprotective eyewear. In addition, 86% ($n = 227$) reported always using leaded gowns and 61% ($n = 161$) thyroid shields (Figure 2). The most commonly cited reasons for not using radioprotective eyewear were that the institution did not supply them, that the respondent did not know where to purchase them, and that the respondent was unaware of a possible cataract risk (Table II).

Association Between Perceived Risk of Cataracts and Awareness of Risk and Dose Limits

Sixty-eight percent ($n = 98$) of respondents who indicated that they were at least fairly aware of the risk of cataractogenesis due to ionizing radiation perceived that their personal risk was at least moderately or extremely high. Only 24% ($n = 29$) of respondents who indicated that they had a lower level of awareness regarding cataract risk (no or only minimal awareness), perceived their personal risk as being moderately or extremely high (Table III). The association between perceived risk and awareness was significant ($P < .001$).

Those respondents who indicated that they were at least fairly aware of dose limits were again more likely to perceive themselves as being at moderate to extreme risk of cataractogenesis ($n = 38$; 58%) than those respondents who indicated being not or only minimally aware ($n = 89$; 45%; $P = .06$) (Table IV).

Comparing each respondent's estimated fluoroscopy use and the perceived risk of cataractogenesis (Table V) demonstrated that as the estimated fluoroscopy use increased, so did the percentage of respondents who perceived themselves to be at least moderate or extreme risk (42%, 57%, and 67%, respectively; $P = .02$).

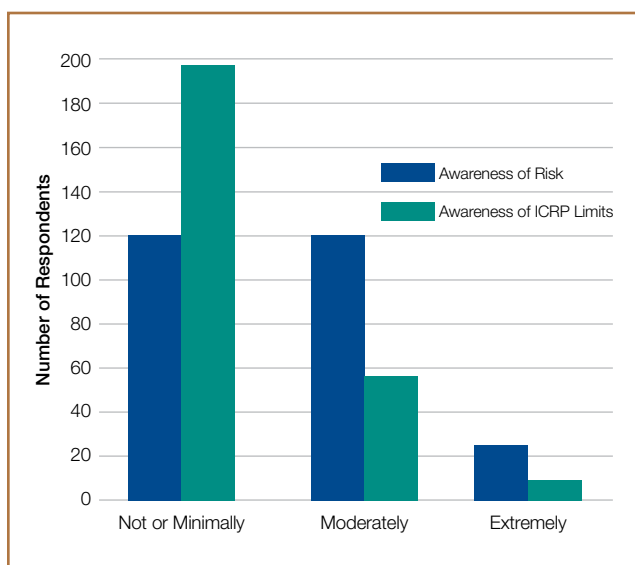


Figure 1. Awareness of causation of cataracts by ionizing radiation exposure and Awareness of International Commission on Radiological Protection (ICRP) limits.

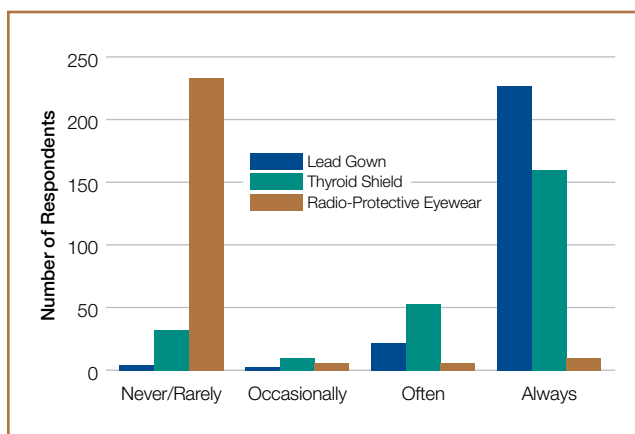


Figure 2. Reported use of radio-protective equipment during occupational exposure to ionizing radiation.

Discussion

We hypothesized that orthopedic surgeons and residents would perceive themselves to be at low risk for cataract formation. However, we found that almost half of respondents perceived themselves to be at either moderate or extreme risk for cataract formation due to occupational exposures. This perceived risk was present despite a very limited awareness among respondents regarding the role of radiation in cataractogenesis. The questionnaire did not specifically attempt to elucidate why orthopedic surgeons believe themselves to be at risk.

Importantly, the questionnaire responses highlight that many orthopedic surgeons lack the information required to make informed decisions about cataract risk and the use of radioprotective eyewear. Almost a quarter of respondents

Table II. Reasons for Not Using Radio-Protective Eyewear

Reasons	Percentage*
Not provided by institution	55
Unaware of where to purchase	38
Unaware of possible cataract risk	26
Did not know that leaded glasses exist	24
Expensive to purchase	22
Uncomfortable to wear	16
Inconvenient to bring to operating room	16
No perceived cataract risk	11
Believe they are not compatible with prescription eyewear	8
Believe that prescription glass lenses provide radiation protection	1

Does not equal to 100% because respondents could choose multiple options; n = 264

directly acknowledged that they did not possess sufficient information to estimate their cataract risk, and nearly 60% were unable to estimate their radiation exposure relative to the ICRP annual dose limit. This lack of information appears to affect surgeons' risk perceptions as those surgeons who reported that they were less aware of the cataractogenesis risk due to radiation exposure and the existence of dose limits also reported lower perceptions of risk.

Lack of information was also an important determinant of surgeons' use of radioprotective eyewear. Although the most common reason for not using radioprotective eyewear was

that it was not provided by the institution, next most common reasons were that surgeons were unaware of where to purchase the eyewear, that they were unaware of a possible cataract risk due to radiation exposure, and that they did not know that leaded glasses exist. Our findings support the recent review by Lester and colleagues³² describing the potentially hazardous work environment of orthopedic surgeons and lack of preventative measures. This study demonstrates a large information deficit among orthopedic surgeons regarding radiation safety and their ophthalmologic health.

To preserve confidentiality, responses were not linked to any identifying data, such as surgeon location within Canada. As such, we were unable to perform any analysis by specific hospitals or health regions to determine if there were regional or institutional differences. Furthermore, although we used population-based sampling, only 23% of eligible respondents participated. Thus, there may be some potential for respondent bias in that surgeons with higher levels of perception and/or awareness of cataract risk may have been more likely to complete the questionnaire. However, based on the number

of respondents who indicated that they were unaware of the risk and unaware of dose limits, it does not appear that these particular respondents were well informed.

Recent epidemiological studies have shown elevated incidences of lens opacities and cataracts in the areas of interventional cardiology and interventional radiology.³⁷⁻⁴⁰ Two international studies^{37,40} reported that the prevalence of radiation-associated posterior lens opacities was 38-52% for interventional cardiologists, 21-45% for nurses, and 9-12% for controls. Relative to controls, the relative risk of lens opac-

Table III. Perception of Personal Risk, Compared With Awareness of Risk

Awareness of Risk	Perception of Personal Risk		
	No or Minimal	Moderate-Extreme	Inadequate Information to Make a Decision
Not/Minimally (n = 120)	44 (37%)	29 (24%)	47 (39%)
Fairly-Extremely (n = 144)	34 (24%)	98 (68%)	12 (8%)

P<.001 by Chi Square Test

Table IV. Perception of Personal Risk, Compared With Awareness of Dose Limits

Awareness of Dose Limits	Perception of Personal Risk		
	No or Minimal	Moderate-Extreme	Inadequate Information to Make a Decision
Not/Minimally (n = 197)	58 (29%)	89 (45%)	50 (25%)
Fairly-Extremely (n = 66)	20 (30%)	38 (58%)	8 (12%)

P = .06 by Chi Square Test

Table V. Perception of Personal Risk, Compared With Reported Exposure

Reported Exposure	Perception of Personal Risk		
	No or Minimal	Moderate–Extreme	Inadequate Information to Make a Decision
Low (<300 s/week), n = 197	51 (35%)	62 (42%)	34 (23%)
Moderate (301-599 s/week), n = 66	9 (18%)	29 (57%)	13 (26%)
High (>600 s/week), n = 39	9 (23%)	26 (67%)	4 (10%)

P = .02 by Chi Square Test

ity was 3.2-5.7 (95% CI: 1.0-22.0) for interventional cardiologists and 1.7-5.0 (95% CI: 0.80-21.0) for nurses. Both reports emphasized the need to educate exposed professionals about the importance of radioprotective eyewear.

Recently the Royal College of Physicians and Surgeons of Canada have included radiation safety as a training objective for all surgical residents.⁴¹ This topic is currently not covered by the American College of Graduate Medicine (ACGME) or the American College of Surgeons (ACS) objectives of training; both major curricular bodies in the United States. The Australian Orthopaedic Association has recently published a booklet⁴² on the topic and The Royal College of Australasian Surgeons include this topic in their Orthopaedic Principles and Basic Science (OPBS) Examination. Focusing on resident education and formative assessment of radiation practices during training should initiate a change in practice.

In conclusion, a large information deficit was reported by orthopedic surgeons with respect to awareness of the potential risks of cataractogenesis due to radiation exposure and of the existence of dose limits. More than 90% of respondents do not use radioprotective eyewear. Given the number of recent studies that are significant for the formation of cataracts at much lower doses of radiation exposure than the current ICRP guidelines, there is a definite need to educate practicing orthopedic surgeons and trainees about the potential risks of radiation exposure.

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