

Intraoperative Radiation Exposure During Hip Arthroscopy

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Background: The frequency of hip arthroscopy for the treatment of acute and chronic chondrolabral pathology and femoroacetabular impingement (FAI) has increased exponentially over the past decade. While surgeon and patient radiation exposure has been well documented in other areas of the orthopaedic literature, little is known about the procedure-specific and cumulative doses affecting the hip arthroscopist.

Purpose: To determine the mean annual radiation exposure to the hip arthroscopist and the mean surgeon exposure per case.

Study Design: Case series; Level of evidence, 4.

Methods: A total of 210 consecutive hip arthroscopies performed in 209 patients by a single surgeon at a single ambulatory surgical center in a cohort consisting of approximately 50% bony (cam and pincer) pathology were prospectively reviewed, documenting the specific procedures performed in each case and the readings from a radiation dosimeter worn by the surgeon during positioning and while performing the procedures. Radiation readings for deep dose–equivalent (DDE), lens dose–equivalent (LDE), and shallow dose–equivalent (SDE) were measured. These readings were compared with the annual radiation dose limit recommendations established by the International Commission on Radiological Protection (ICRP).

Results: The total radiation doses for the operative surgeon during all 210 cases were 183 mrem (1.83 mSv) DDE, 183 mrem (1.83 mSv) LDE, and 176 mrem (1.76 mSv) SDE. The mean exposure per case was 0.871 mrem (0.00871 mSv) DDE, 0.871 mrem (0.00871 mSv) LDE, and 0.838 mrem (0.00838 mSv) SDE. The operative surgeon's mean annual exposure, performing 70 hip arthroscopies per year with 55% involving bony work, was 61.0 mrem (0.610 mSv) DDE, 61.0 mrem (0.610 mSv) LDE, and 58.7 mrem (0.587 mSv) SDE. These results are well below the ICRP annual limits of 50,000 mrem (500 mSv) DDE, 2000 mrem (20 mSv) LDE, and 50,000 mrem (500 mSv) SDE.

Conclusion: For an experienced hip arthroscopist utilizing fluoroscopy during setup and bony resection, the annual and per-patient exposure to radiation remains well below the recommended ICRP limits.

Clinical Relevance: Considering the increasing annual frequency of hip arthroscopies being performed, information regarding procedure-specific and cumulative doses of radiation exposure affecting the hip arthroscopist may provide valuable safety information for the orthopaedic community.

Keywords: hip; arthroscopy; radiation; fluoroscopy

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The frequency of hip arthroscopy for the treatment of acute and chronic chondrolabral pathology and femoroacetabular impingement (FAI) has increased exponentially over the past decade.² Intraoperative fluoroscopy is commonly used during the procedure to confirm appropriate distraction and to ensure adequate resection of FAI. The latter has been noted to be of particular importance, as underresection of femoral or acetabular pathology can lead to residual impingement, whereas overresection has been linked to postoperative instability or even risk of a catastrophic femoral neck fracture.^{1,21}

While surgeon and patient radiation exposure has been well documented in the trauma and spine literature,^{17,18} little is known about the procedure-specific and cumulative

TABLE 1
Patient Demographic Characteristics

| | |
|---|------------------|
| Total patients, n | 209 |
| Males, n (%) | 87 (41.6) |
| Females, n (%) | 122 (58.4) |
| Age, y, mean (range) | 33.6 (14-77) |
| Body mass index, kg/m ² , mean (range) | 24.7 (16.1-45.0) |

TABLE 2
Body Mass Index

| Body Mass Index, kg/m ² | Weight Status | n | % |
|------------------------------------|---------------|-----|------|
| <18.5 | Underweight | 8 | 3.8 |
| 18.5-24.9 | Normal | 114 | 54.5 |
| 25-29.9 | Overweight | 62 | 29.7 |
| ≥30.0 | Obese | 25 | 12.0 |

doses affecting the hip arthroscopist. The International Commission on Radiological Protection (ICRP) put forth guidelines setting limits on annual radiation exposure in an attempt to minimize potential risks of exposure to both the surgeon and the patient.¹¹ Canham et al⁴ reported the radiation exposure of patients undergoing hip preservation procedures while also evaluating occupational risk to operating room personnel. They found that greater body mass index (BMI) correlated with increased occupational exposure.⁴ In light of the limited research on radiation exposure to the surgeon during fluoroscopic-assisted hip arthroscopy, we sought to determine the average annual intraoperative radiation exposure to the hip arthroscopist.

METHODS

Between July 2011 and July 2014, a total of 210 consecutive hip arthroscopies were performed in 209 patients by a single surgeon at a single ambulatory surgical center in a cohort consisting of approximately 50% bony (cam and pincer) pathology. At the time of the study, the operative surgeon was an experienced hip arthroscopist with 6 years of experience who performed an average of 75 to 100 hip arthroscopies per year. Institutional review board approval was obtained prior to study initiation.

All patients undergoing hip arthroscopy at the single outpatient center during the study period were included in the study. Exclusion criteria included patients undergoing alternate procedures, such as periacetabular osteotomy, that could affect the fluoroscopy used intraoperatively. The specific procedures performed in each case were recorded. In addition, patient demographics including age, sex, and BMI were recorded (Tables 1 and 2). A radiation dosimeter (Landauer) was worn on the outside chest of the lead apron of the surgeon during preoperative positioning and for the duration of the procedure. Exposure was not recorded at the end of each case; rather, the dosimeter was read periodically throughout the study period to document cumulative radiation exposure to the surgeon. In accordance with

our radiation safety protocol, the following radiation readings were measured: deep dose-equivalent (DDE), the external whole-body exposure dose equivalent at a tissue depth of 1 cm (1000 mg/cm²); lens dose-equivalent (LDE), the external exposure dose equivalent to the lens of the eye at a tissue depth of 0.3 cm (300 mg/cm²); and shallow dose-equivalent (SDE), the external exposure dose equivalent to the skin or an extremity at a tissue depth of 0.007 cm (7 mg/cm²) averaged over an area of 1 cm². Cumulative radiation exposure was tabulated in millirems (mrem) and converted to milli-Sieverts (mSv [measure of radiation dosage]), which is the standard measurement used by the ICRP. An estimation of the operative surgeon's annual exposure was calculated from the data pool. Descriptive statistical analysis was performed using R Statistical Software (Foundation for Statistical Computing).

Surgical technique involved standard positioning in a hip distractor (Smith & Nephew Active Heel). A standard, mobile C-arm unit (Phillips) was used, and all images were taken by an x-ray technician under the direction of the surgeon. Preoperative views included anterior-posterior (AP) pelvis, AP hip, 45° Dunn view, lateral, internal, and external rotation views to isolate the optimum view of the cam lesion (if applicable), and a final AP pelvis after traction had been applied to ensure distractibility of the joint. Intraoperatively, imaging was taken to localize the path of a spinal needle used to penetrate the joint capsule, to verify the "air arthrogram" on removing the stilette from the needle, and on introduction of the trocar to ensure capsule penetration. The senior author (J.P.S.) typically utilized 2 portals with interportal capsulotomy to evaluate the peripheral compartment for cam lesions. Depending on the case, the portals were anterior peritrochanteric or anterolateral, modified anterior, or midanterior. C-arm imaging was used as needed for the initial portal.

For patients with pincer lesions, a single image was taken after the acetabuloplasty to ensure adequate resection. For those with cam lesions, images were taken initially to localize the starting point of the femoroplasty at the epiphyseal scar, then at various points during the procedure to ensure proper resection.

RESULTS

A total of 55.02% of the cases (115 of the 209 patients) involved bony work that would utilize additional fluoroscopy. In total, these patients underwent 79 femoroplasties, 64 acetabuloplasties, and 6 resections of subspine impingement. The specific procedures and frequency of each performed in this cohort of patients are presented in Table 3.

The total radiation doses calculated for the operative surgeon during the 210 cases were 183 mrem (1.83 mSv) DDE, 183 mrem (1.83 mSv) LDE, and 176 mrem (1.76 mSv) SDE. According to these data, the average exposure per case was 0.871 mrem (0.00871 mSv) DDE, 0.871 mrem (0.00871 mSv) LDE, and 0.838 mrem (0.00838 mSv) SDE. The average annual exposure for the operative surgeon performing approximately 70 hip arthroscopies per year with 55% involving bony work was 61.0 mrem (0.610 mSv)

TABLE 3
Types of Procedures Performed

| Procedure | Frequency |
|---|-----------|
| Labral repair | 107 |
| Labral debridement | 94 |
| Chondroplasty | 88 |
| Synovectomy | 82 |
| Femoroplasty | 79 |
| Acetabuloplasty | 64 |
| Capsulotomy | 34 |
| Trochanteric bursectomy | 23 |
| Loose body removal | 19 |
| Debridement of partial ligamentum teres tear | 14 |
| Iliopsoas release | 10 |
| Capsule closure | 7 |
| Scar excision | 7 |
| Microfracture | 7 |
| Decompression of subspine impingement | 6 |
| Gluteus minimus/medius repair | 5 |
| Iliopsoas lengthening | 3 |
| Other (ie, synovial biopsy, cyst aspiration, iliotibial band release) | 10 |
| Total | 659 |

DDE, 61.0 mrem (0.610 mSv) LDE, and 58.7 mrem (0.587 mSv) SDE (Table 4). These results are well below the ICRP annual limits of 50,000 mrem (500 mSv) DDE, 2000 mrem (20 mSv) LDE, and 50,000 mrem (500 mSv) SDE.¹¹

DISCUSSION

The annual frequency of hip arthroscopies has increased dramatically in recent years, particularly for the treatment of FAI and osteoarthritis.² Moreover, radiation exposure to the surgeon, the health care team, and the patient during arthroscopic hip surgery are valid concerns. A 2013 analysis of trends in hip arthroscopy found a 600% increase in arthroscopic hip procedures among board-certification reporting from 2006 to 2010,² with multiple studies noting a shift from simple soft tissue debridements to significant osteoplasties as the technique has become more streamlined.^{2,13,15} While the use of fluoroscopy is an essential component to ensure appropriate distraction, safe cannula placement, and adequate bony resection, it also comes with an increase in radiation exposure to those involved in the procedure.

The ICRP advocates a system of protection against the detrimental effects of ionizing radiation that is based on optimization of protection through the establishment of individual dose and risk limits and the requirement that any exposure to ionizing radiation must be justified by the provision of societal benefits.⁸ The ICRP recommendations are based on the growing body of scientific knowledge in the field of radiobiology and the judgment of experts in radiological protection. The ICRP takes into account both the stochastic (cancer/heritable effects) and deterministic (tissue/organ damage and developmental defects) effects

TABLE 4
Radiation Exposure^a

| | mrem | mSv |
|--------------------------|-------|---------|
| Cumulative radiation | | |
| DDE | 183 | 1.83 |
| LDE | 183 | 1.83 |
| SDE | 176 | 1.76 |
| Per case radiation | | |
| DDE | 0.871 | 0.00871 |
| LDE | 0.871 | 0.00871 |
| SDE | 0.838 | 0.00838 |
| Average annual radiation | | |
| DDE | 61.0 | 0.610 |
| LDE | 61.0 | 0.610 |
| SDE | 58.7 | 0.587 |

^aDDE, deep dose equivalent; LDE, lens dose equivalent; SDE, shallow dose equivalent.

of ionizing radiation.⁸ The ICRP has various subcommittees that make recommendations based on evaluation of basic science and epidemiological studies, and these recommendations are used to establish regional, national, and international safety standards.

Radiation exposure has been linked to a number of health hazards, including cataracts and oncologic processes.^{6,16,23,25} Chodick et al⁶ reported that radiologic technologists with higher cumulative occupational radiation exposure to the lens of the eye (mean, 60.1 milligrays [mGy; measure of radiation exposure]) were noted to have an adjusted hazard ratio of cataract of 1.18 compared with those with lower exposure levels (mean, 5.1 mGy) despite being well below the minimum cataractogenic dose of 2000 mGy cited by the ICRP at the time of the study.⁶ Moreover, while the association between ionizing radiation exposure and oncologic processes has been well documented, there is currently no universally accepted threshold dose at which there is a measurable increase in cancer risk. Epidemiologic studies may not be able to detect the effects of very low radiation doses because there is limited statistical power at cumulative lifetime radiation levels of less than 100 mSv.¹⁶ Considering that increased cancer prevalence rates among orthopaedic surgeons have been reported,⁷ there is a need to elucidate the role of chronic exposure to occupational ionizing radiation.

In light of the association between radiation exposure and the aforementioned health hazards, the "ALARA" (as low as reasonably achievable) principle has been advocated to reduce occupational radiation exposure.¹⁴ However, various reports indicate that compliance with and knowledge regarding radiation exposure and protective measures among operating room personnel, including orthopaedic surgeons, is lacking.^{12,22} Saroki et al²² surveyed 91 practicing attending orthopaedic surgeons and found that the majority lacked detailed knowledge regarding radiation safety during surgical treatment for FAI, thereby highlighting the need for radiation safety education in residency training and beyond. Gendelberg et al⁹ demonstrated that a formal radiation safety training program resulted in

significantly decreased radiation exposure to both orthopaedic residents and patients. Moreover, Müller et al¹⁹ reported that the use of real-time dosimetry during various fracture fixation procedures significantly reduced surgeon radiation exposure.

Previously reported rates of exposure in the spine literature show that, during an average fluoroscopically assisted case utilizing spinal instrumentation, the average total radiation exposure to the patient was 5.69 mSv.¹⁸ Meanwhile, in the orthopaedic trauma literature it has been noted that, during a simulated trauma case, the deep exposure for the surgeon and first assistant was 20 mrem/min (0.2 mSv/min) and 6 mrem/min (0.06 mSv/min), respectively.¹⁷ However, Tasbas et al²⁴ reported that an orthopaedic trauma surgeon and the assistant surgeon who wore dosimeter badges over their lead aprons were exposed to a cumulative radiation dose of 10 mrem and 61 mrem, respectively, over a 3-month period involving 107 consecutive trauma operations.²⁴ This discrepancy between surgeon and assistant surgeon dose readings was attributed to differences in distance from the x-ray source.

Budd et al³ quantified radiation exposure in a sample of 50 consecutive patients undergoing fluoroscopic-assisted arthroscopic hip surgery by a single surgeon and concluded that patient exposure was well below permissible limits. However, there is a paucity of literature on surgeon radiation exposure during fluoroscopic-assisted hip arthroscopy. This study documented both a cumulative and average annual radiation exposure that was considerably lower than the ICRP-recommended limits, a figure consistent with previously published reports. Canham et al⁴ calculated the radiation exposure to both the surgeon and individual members of the surgical team as determined by their proximity to the surgical field and found an average radiation exposure of 7 to 9 mrem per 50 hip arthroscopies performed and a positive correlation between cumulative radiation exposure and patient BMI.⁴ The average BMI for our sample was 24.7 kg/m², which is slightly below the reported average BMI of 26.6 and 26.5 kg/m² for adult American men and women, respectively.⁵ However, it is important to note that our sample also included several adolescents younger than 18 years. Nevertheless, the mean BMI of our sample is comparable to that reported by Canham et al.⁴ The discrepancy between the average annual radiation dose found in the present study and that of Canham et al⁴ may be explained by differences in the distance of the operative surgeon from the x-ray source, as this appears to be a major determinant of radiation exposure dose as noted in the trauma literature cited above. It is also important to note that in the study by Canham et al,⁴ automatic measurements of radiation exposure were generated by the fluoroscopy unit and dose calculations were performed by a radiologist.⁴ Therefore, variability in the aforementioned factors may explain the discrepancy between our results and those of Canham et al.⁴

While some authors have suggested techniques to minimize radiation exposure by introducing cannulas and creating portals under direct visualization rather than utilizing fluoroscopy,^{10,20} the majority of contemporary hip

arthroscopists rely on radiologic guidance, and our findings suggest that this practice involves radiation exposure levels that are well below the annual limits set forth by the ICRP. Moreover, it is also important to note that the dosimeter is worn outside of the lead apron and with proper eye protection; therefore, the actual doses received to the major organs and eyes were likely much lower than the values recorded in this study.

This study is certainly subject to a number of limitations. First, there is significant variability in the amount of fluoroscopy utilized during a case, much of which depends on surgeon experience, patient factors (BMI), diagnosis, and whether a fellow or resident are involved in the procedure. It is therefore important to note that this was the radiation exposure of a single experienced hip arthroscopist and may not reflect all-comers in the general community. It is also important to note that arthroscopies performed in teaching settings or by inexperienced hip arthroscopists would likely involve higher radiation exposure levels. In addition, the degree of bony deformity and the patient's BMI would certainly affect the amount of fluoroscopy used, as heavier patients and larger bony deformities would likely necessitate greater amounts of radiation exposure. Moreover, we did not include preoperative radiographic measurements of alpha angles or lateral center-edge angles, in part because our data collection did not allow for a per case correlation of radiation exposure. Nevertheless, these case-dependent variations in radiation dose should be considered.

Despite the aforementioned limitations, our findings contribute to the literature on this topic, as there is currently a paucity of research on surgeon exposure to radiation during fluoroscopic-assisted arthroscopic hip procedures. Although reporting of case-specific fluoroscopy time and radiation exposure would be useful, our study sought to quantify cumulative radiation exposure for an experienced hip arthroscopist and determine its relation to the radiation exposure limits set forth by the ICRP. Given that fluoroscopy is widely used among hip arthroscopists and poses a potential occupational hazard, it is important to quantify cumulative exposure in order to ascertain the risks incurred by its routine use. Moreover, as the trend toward increasing utilization of fluoroscopic-assisted arthroscopic hip surgery increases, it certainly stands to reason that cumulative radiation exposure for orthopaedic surgeons performing these procedures will invariably increase.

Although this study demonstrated that cumulative radiation exposure for an experienced hip arthroscopist was well within permissible limits, conclusions cannot be drawn regarding the potential carcinogenic effects of the reported exposure level. Needless to say, in light of what is known about the detrimental effects of ionizing radiation, any amount of radiation exposure poses an occupational hazard. Therefore, despite evidence suggesting that radiation exposure during fluoroscopic-assisted arthroscopic hip surgery remains well below the ICRP's annual limits, the importance of taking appropriate safety precautions and routinely monitoring radiation dose should not be overlooked.

CONCLUSION

A number of variables can influence the actual dose of radiation per case, including surgeon experience, extent of pathology, distance from the x-ray source, and the patient's BMI. Our findings highlight that cumulative radiation exposure for an experienced hip arthroscopist performing 210 consecutive arthroscopies remained well below the annual ICRP thresholds, thereby suggesting that even surgeons in their learning curve or those treating patients with extreme FAI should feel reasonably comfortable relying on fluoroscopy to ensure safe, complete, and precise arthroscopic osteoplasty while taking appropriate safety precautions.

REFERENCES

- Bardakos NV, Vasconcelos JC, Villar RN. Early outcome of hip arthroscopy for femoroacetabular impingement: the role of femoral osteoplasty in symptomatic improvement. *J Bone Joint Surg Br.* 2008;90:1570-1575.
- Bozic KJ, Chan V, Valone FH 3rd, Feeley BT, Vail TP. Trends in hip arthroscopy utilization in the United States. *J Arthroplasty.* 2013;28(suppl 8):140-143.
- Budd H, Patchava A, Khanduja V. Establishing the radiation risk from fluoroscopic-assisted arthroscopic surgery of the hip. *Int Orthop.* 2012;36:1803-1806.
- Canham CD, Williams RB, Schiffman S, Weinberg EP, Giordano BD. Cumulative radiation exposure to patients undergoing arthroscopic hip preservation surgery and occupational radiation exposure to the surgical team. *Arthroscopy.* 2015;31:1261-1268.
- Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey. Healthy weight, overweight, and obesity among U.S. adults. <http://www.cdc.gov/nchs/data/nhanes/databriefs/adultweightpdf>. Accessed March 1, 2017.
- Chodick G, Bekiroglu N, Hauptmann M, et al. 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;168:620-631.
- Chou LB, Lerner LB, Harris AH, Brandon AJ, Girod S, Butler LM. Cancer prevalence among a cross-sectional survey of female orthopedic, urology, and plastic surgeons in the United States. *Womens Health Issues.* 2015;25:476-481.
- Clarke RH, Valentin J. The history of ICRP and the evolution of its policies. ICRP publication 109. *Ann ICRP.* 2009;39:75-110.
- Gendelberg D, Hennrikus W, Slough J, Armstrong D, King S. A radiation safety training program results in reduced radiation exposure for orthopaedic residents using the mini C-arm. *Clin Orthop Relat Res.* 2016;474:580-584.
- Howse EA, Botros DB, Mannava S, Stone AV, Stubbs AJ. Basic hip arthroscopy: anatomic establishment of arthroscopic portals without fluoroscopic guidance. *Arthrosc Tech.* 2016;5:e247-e250.
- International Commission on Radiological Protection. Dose limits recommended by ICRP. <http://www.icrp.org/icrpaedia/limits.asp>. Accessed March 1, 2017.
- Jentzsch T, Pietsch CM, Stigler B, Ramseier LE, Seifert B, Werner CM. The compliance with and knowledge about radiation protection in operating room personnel: a cross-sectional study with a questionnaire. *Arch Orthop Trauma Surg.* 2015;135:1233-1240.
- Kandil A, Safran MR. Hip arthroscopy: a brief history. *Clin Sports Med.* 2016;35:321-329.
- Kaplan DJ, Patel JN, Liporace FA, Yoon RS. Intraoperative radiation safety in orthopaedics: a review of the ALARA (as low as reasonably achievable) principle. *Patient Saf Surg.* 2016;10:27.
- Kivlan BR, Nho SJ, Christoforetti JJ, et al. Multicenter outcomes after hip arthroscopy: epidemiology (MASH Study Group). What are we seeing in the office, and who are we choosing to treat? *Am J Orthop (Belle Mead NJ).* 2017;46:35-41.
- Linert MS, Slovis TL, Miller DL, et al. Cancer risks associated with external radiation from diagnostic imaging procedures. *CA Cancer J Clin.* 2012;62:75-100.
- Mehlman CT, DiPasquale TG. Radiation exposure to the orthopaedic surgical team during fluoroscopy: "how far away is far enough?". *J Orthop Trauma.* 1997;11:392-398.
- Mendelsohn D, Strelzow J, Dea N, et al. Patient and surgeon radiation exposure during spinal instrumentation using intraoperative computed tomography-based navigation. *Spine J.* 2016;16:343-354.
- Müller MC, Welle K, Strauss A, et al. Real-time dosimetry reduces radiation exposure of orthopaedic surgeons. *Orthop Traumatol Surg Res.* 2014;100:947-951.
- Nogier A, Boyer T, Khan MT. Hip arthroscopy: less invasive technique. *Arthrosc Tech.* 2014;3:e101-e106.
- Papavasiliou AV, Bardakos NV. Complications of arthroscopic surgery of the hip. *Bone Joint Res.* 2012;1:131-144.
- Saroki AJ, Wijdicks C, Philippon MJ, Bedi A. Orthopaedic surgeons' use and knowledge of ionizing radiation during surgical treatment for femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc.* 2016;24:3962-3970.
- Singer G. Occupational radiation exposure to the surgeon. *J Am Acad Orthop Surg.* 2005;13:69-76.
- Tasbas BA, Yagmurlu MF, Bayrakci K, Ucaner A, Heybeli M. Which one is at risk in intraoperative fluoroscopy? Assistant surgeon or orthopaedic surgeon? *Arch Orthop Trauma Surg.* 2003;123:242-244.
- Vano E, Kleiman NJ, Duran A, Rehani MM, Echeverri D, Cabrera M. Radiation cataract risk in interventional cardiology personnel. *Radiat Res.* 2010;174:490-495.