

Use of Radiographic Imaging Protocols by Canadian Memorial Chiropractic College Interns

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Objectives: The purpose of this study was to determine if 4th-year interns plan to x-ray their patients, once they are in private practice, in accordance with the principles taught throughout their radiology program and with the evidence-based imaging guidelines outlined in the literature. **Methods:** Questionnaires were provided to all 4th-year interns. Each questionnaire consisted of 10 case scenarios representing possible chiropractic patients. Each intern was asked if he or she would radiograph the patient and, if so, which views would be taken. A "gold standard" was established by two chiropractic radiologists using evidence-based guidelines. Intern answers were compared with the gold standard using percent agreement. **Results:** Sixty-eight interns completed the questionnaire. Agreement between the interns and the gold standards for the question of whether or not they would take x-rays ranged from 63.2% to 100%. The percent agreement for the correct radiographic views chosen ranged from 32.6% to 48.4%. **Conclusion:** Interns are generally aware of and plan to apply the radiographic guidelines for determining whether or not radiographs are indicated, as outlined in the current literature. However, interns are inconsistent in choosing the correct views. (The Journal of Chiropractic Education 21(2): 144-152, 2007)

Key Indexing Terms: chiropractic; education; radiation, ionizing; radiography; x-ray guidelines; x-rays

INTRODUCTION

Plain-film radiography is widely used in chiropractic clinical practice and it is considered a vital tool in reaching a proper and accurate diagnosis for some patients. The American Chiropractic Association estimates that 80% of private chiropractic offices have the necessary equipment to produce plain-film radiographs.¹ Chiropractors must be prepared to recognize, manage, or refer pathologies discovered on radiographs, making diagnostic radiology an important component of chiropractic education.

In recent years, the dangers of exposure to ionizing radiation have become evident. Studies have shown that the risk of cancer increases with increased numbers of radiographic exposures and with

cumulative radiation dose.²⁻⁴ It is generally accepted that radiographs should be requested based on sound clinical judgment, and when the results of the radiographs will have an influence on patient management.⁵

Evidence-based guidelines and rules have been developed to help health care practitioners determine the need for radiographs. Based on history and physical examination findings, Simmons et al.⁵ have offered a list of specific "red flag" indicators for lumbar spine x-rays on patients with low back pain of less than 7 weeks duration. Rules and guidelines for radiographs of the cervical spine are not as clearly outlined and most of the available literature pertains to trauma and inflammatory arthropathies.^{6,7} Specific information pertaining to indications for thoracic spine radiographs alone does not exist.⁶ However, many of the indications proposed for lumbar spine radiographs can also be applied to the thoracic and cervical spine areas.⁶ Common

indications for extremity radiographs include trauma and the evaluation of arthritic symptoms. Less common indicators include symptoms of infection, history or clinical findings of a tumor, and evaluation of gross deformities.⁶

The use of radiographs for biomechanical analysis is a source of controversy within the chiropractic profession. However, there are conditions, such as scoliosis, in which radiographic structural and biomechanical information is vital to diagnosis and treatment.⁶ Intersegmental hypermobility, instability, and spondylolytic spondylolistheses are other biomechanical conditions detected and assessed through the use of plain-film spinal radiographs.⁶

Current guidelines also outline minimal diagnostic series in order to reduce a patient's exposure to ionizing radiation. For example, only two views (anteroposterior [AP] or posteroanterior [PA] and lateral) are necessary for radiographic examination of the lumbar spine.⁶ Other views, including the spot angled lumbosacral view and lumbar oblique views are seldom needed and should only be ordered when it can be reasoned that the results will affect patient management. For most regions of the musculoskeletal system, at least two views at 90° to each other constitute a minimal diagnostic series. However, there are exceptions to this rule, such as the cervical spine, wrist, hand, ankle, and foot,

where three views are considered minimal, and the pelvis, where a single view can be a complete series⁶ (Tables 1 and 2).

Students at the Canadian Memorial Chiropractic College (CMCC) undergo an intensive 4-year training program. Their chiropractic education includes a 3-year course of radiographic interpretation encom-

Table 1. Spinal Radiographic Views

Area	Minimal series	Supplementary views
Cervical spine	AP lower cervical, neutral lateral	AP open mouth Flexion/extension Obliques Pillar
Thoracic spine	AP, lateral	Swimmer's lateral
Lumbar spine	PA (or AP), lateral	Spot angled lumbosacral Spot lateral lumbosacral Obliques Flexion/extension
Pelvis	AP	
Full spine	PA (or AP) for scoliosis	Right and left lateral bending Sectional laterals

Table 2. Extremity Radiographic Views

Area	Minimal series	Supplementary views
Shoulder (nontrauma)	AP internal and external rotation (baby arm)	AP neutral and transthoracic lateral or Y view of scapula (Baby arm) (axillary view)
A/C joints	AP weightbearing and nonweightbearing	Bilateral comparison
Elbow	AP and lateral	Oblique (medial or lateral) AP with hand pronation
Wrist	PA, medial oblique, lateral	PA with ulnar deviation Lateral oblique Norgaard's (ball-catcher's) projection
Hand	PA, medial oblique, lateral	Single finger views (PA and lateral)
Hip (nontrauma)	AP or AP pelvis and frog leg	True lateral hip
Knee	AP and lateral	Tunnel Sunrise
Ankle	AP, medial oblique, lateral	
Foot	Dorsoplantar, medial oblique, lateral	For toes, use a sponge to straighten out the toes. Axial view calcaneus

passing a wide range of congenital anomalies, arthritic conditions, neoplastic lesions, and other pathologies. In addition, during the course of their 4th-year internship, students must complete a 70-hour x-ray technology clerkship and a 30-hour radiology interpretation clerkship. Radiation dose considerations, case management, and interdisciplinary referral are integral parts of all radiology courses taught at CMCC.

The purpose of this study was to determine if CMCC 4th-year interns, who are being prepared to enter the chiropractic profession, will choose to x-ray their patients in accordance with the principles taught through the radiology program at CMCC and with the evidence-based guidelines outlined in the literature once they are in private practice. We sought to examine the ability of chiropractic interns to detect and recognize the need to x-ray patients and determine the relevant diagnostic series as taught at CMCC and described in current literature. In addition, we wanted to determine whether interns will take unnecessary radiographs, thus exposing patients to avoidable ionizing radiation.

METHODS

A questionnaire consisting of 10 case scenarios was administered to a clinical class. The scenarios represented possible chiropractic patients and their complaints and were put together by the researchers to represent a variety of cases where radiographs may or may not be warranted. The cases represented times when it was essential to take radiographs, times when radiographs were definitely not needed, and times when the necessity of taking radiographs was more vague and subjective. The cases were evaluated for face and content validity by a Diplomate of the American Board of Radiology (DACBR) prior to administration.

The questionnaire asked the clinical intern if he or she would radiograph that patient and, if so, which

specific radiographs would be taken. A list of all the possible radiographic views was provided and the intern was required to check off those that he or she would take. Following this section, there was space provided for further comment about the decision made. A total of 130 questionnaires/surveys were printed and handed out. The student interns were given a few hours to 2 days to complete them. The main objective was to compare how many interns would take radiographs of the patients, and if they were in accordance with the gold standard.

The gold standard was established by two DACBRs at CMCC using published imaging guidelines. The chiropractic radiologists were administered the surveys before the clinical interns received them, and agreed on the answers together, and their results were compared with those of the students.

Statistical analysis was done for each case using percent agreement. A comparison was made between the gold standard and the students' answers in two areas: 1) whether or not the student would take a radiograph of the patient in the clinical vignette, and 2) which radiographic views they would select. This study received ethics review board approval from CMCC.

RESULTS

Of the 130 surveys that were distributed, 68 (52%) were completed and returned. The vignette cases were categorized based on whether respondents perceived that radiographs should or should not be taken for that clinical case. There were three categories of responses: a definite yes (an x-ray should be taken), a definite no, and uncertainty due to perceived gray areas. The cases that were generally perceived as "definite yes" were cases 1, 6, and 10. Cases that were generally perceived as "definite no" were cases 2, 5, 7, 8, and 9. Cases that were generally perceived with uncertainty were cases 3 and 4 (Table 3).

Table 3. Summary of Interns' Responses Compared with the Gold Standard

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
YES	64	16	47	48	0	43	16	8	19	64
NO	4	52	20	20	68	25	52	60	49	3
Gold standard	YES	NO	Vague	Vague	NO	YES	NO	NO	NO	YES
% Agreement	94.1	76.5			100	63.2	76.5	88.2	72.1	95.9

For case 1, 64 of 68 respondents (94.1%) stated that they would definitely x-ray the vignette patient, agreeing with the gold standard. For case 2, 52 of 68 (76.5%) respondents stated that they would definitely not x-ray the vignette patient, agreeing with the gold standard assessment. For cases 3 and 4, a percent agreement was not calculated because no agreement could be established between the two gold standard team members, as these cases were purposely created to be vague and ambiguous. Case 5 had 100% agreement with the gold standard assessment, which was to definitely not proceed with x-raying the vignette patient. For case 6, 43 of the 68 respondents agreed with the gold standard to x-ray the vignette patient, for an agreement of 63.2%. For case 7, 52 of the 68 respondents said they would not x-ray their patients, for an agreement of 76.5% with the gold standard. Sixty of the 68 respondents for case 8 agreed with the gold standard not to x-ray their vignette patient, for an agreement of 88.2%. Forty-nine of the 68 respondents in case 9 said they would not x-ray their patients, resulting in 72.1% agreement with the gold standard. Case 10 had 64 of the 68 respondents who agreed with the gold standard to x-ray their vignette patients, for an agreement of 95.5%.

Cases that demonstrated the highest respondent agreement with the gold standard were analyzed further for whether or not the views selected consisted of a complete series (as chosen by the gold standard), an incomplete series (one or more views missing from what was stipulated by the gold standard), a complete series with extra views, an incomplete series with extra views, wrong views, or no views (Table 4). Of the interns who specified that they would take radiographs for cases 1, 6, and 10, 48.4%, 32.56%, and 40.63%, respectively, selected the appropriate views that would be required, without exposing the patient to unnecessary extra radiation. However, 9.4% of respondents for case 1, 32.56% for case 6, and 31.25% for case 10 were prepared to take unnecessary views that would not help in the management of the vignette patients.

DISCUSSION

Chiropractic education in Canada emphasizes the use of current research and guidelines as it pertains to radiography. It has become progressively more important to educate chiropractic students on the unnecessary use of x-rays and the dangers associated

Table 4. X-Ray Views Selected by Respondents as Compared with Those Chosen by the Gold Standard for Vignettes Where Radiographs Were Indicated

X-Ray views	Case 1	Case 6	Case 10
Complete set (gold standard)	48.44%	32.56%	40.63%
Incomplete set	42.19%	32.56%	25%
Complete set with extra views	6.25%	11.63%	25%
Incomplete set with extra views	1.56%	16.28%	6.25%
Wrong views	1.56%	4.65%	0%
No views	0%	2.33%	3.13%

with ionizing radiation. Chiropractors in Canada are among a selected group of health professionals with the right to order and take radiographs in practice. When presented with valid clinical concerns that impact patient management, doctors of chiropractic must demonstrate competence in the use of ionizing radiation, or risk jeopardizing the profession's use of diagnostic radiology.

Canadian chiropractic students undergo an intensive 4-year training program. The objective of the radiology department at CMCC is to provide students with the academic and practical skills necessary for the diagnostic interpretation of radiographs. In their first 3 years, students are exposed to a total of 161 lecture hours and 82 laboratory hours in radiology. Courses focus on topics related to chiropractic practice, including congenital anomalies, arthritic conditions, infection, tumors and tumor-like lesions, fractures and dislocations, metabolic and endocrine disorders, and other radiographic pathologies. Material is presented in a problem-based manner and emphasis is placed on linking clinical findings with diagnostic images as well as using sound clinical judgment in ordering and interpreting the appropriate radiographic studies. In their final year, students enter their clinical training as interns and must complete 1,000 clinic hours. Under the guidance and supervision of licensed clinicians, interns are responsible for patient care and management decisions, including the decision as to whether or not to x-ray a patient. In addition, interns are required to complete

a 70-hour x-ray technology clerkship and a 30-hour radiology interpretation clerkship.

This study aimed to examine the ability of interns to detect and recognize the need to x-ray a patient, to determine whether interns will order the appropriate diagnostic series, and to investigate any unnecessary use of ionizing radiation. Three of the 10 cases presented in this study were designated as “yes” cases. Each of these cases contained “red flags” or indications that justified the use of x-rays and the exposure of the patient to ionizing radiation. This is important because the failure to x-ray a patient with red flags is extremely dangerous, posing not only a risk of litigation against the chiropractor, but also a risk of harm to the patient. In these cases we also asked the interns which views they would take. Current guidelines in the literature outline minimal diagnostic series in order to reduce a patient’s exposure to ionizing radiation, and one of the objectives of this study was to determine whether the interns would expose their patients to excessive radiation by ordering unnecessary views. Tables 1 and 2 list the minimal diagnostic series and supplemental views for each area.⁶ In addition, it is appropriate that a complete diagnostic series be taken in order to correctly visualize all necessary structures, thus allowing the appropriate diagnosis to be made.

The first “yes” case dealt with a woman presenting with diagnosed rheumatoid arthritis (RA), neck pain, and stiffness. It has been established that rheumatoid arthritis targets the cervical spine, favoring the upper cervical area, and potentially may cause spinal instability, brain stem compression, and other potentially serious consequences.^{7,8} RA is the most common of the inflammatory arthropathies, causing erosion of the transverse ligament and subsequent instability of the cervical spine. Students are taught that patients with known inflammatory arthropathies should receive plain-film cervical spine radiographs before neck mobilization and/or manipulation. A diagnostic cervical spine series for the patient presenting with an inflammatory arthropathy should include AP lower cervical, AP open mouth, lateral cervical, and assessment of the atlanto-dento interval (ADI) via a flexion lateral view. Any instability of the upper cervical region is an absolute contraindication to manipulation and the patient should be referred for surgical fusion.⁸ Sixty-four of the 68 respondents in this study chose to x-ray the patient, representing a 94.12% agreement with the gold standard. Of the four interns who chose not to x-ray the patient, one explained that he or she would not

be treating the cervical spine area and would only take cervical spine radiographs if he or she chose to treat that area. Therefore, even though this intern’s response was included with the “no” category, the rationale could be viewed as clinically appropriate. The other three “no” respondents based their decision on the fact that the patient was already diagnosed with RA, and thus missed the importance of checking the ADI. It can be speculated that these interns were either being prudent and thus trying to minimize the patient’s exposure to ionizing radiation, or that they were not planning to include cervical spine treatment in the patient’s management. In any case, they were not practicing in a safe manner for the overall good of the patient.

A complete diagnostic series was ordered by 31 interns (48%), while 27 interns (42%) ordered an incomplete series (usually omitting the flexion lateral view). Four interns (6%) ordered a complete series plus an additional view (usually including an extension lateral view), while one (2%) of the interns ordered an incomplete set with the addition of one wrong view. Finally, one intern ordered the wrong views in general.

The second “yes” case dealt with a woman with low back and neck pain and a history of early menopause (age 45) with no hormone replacement therapy (HRT). One of the red flag indicators for lumbar spine radiography includes a history suggestive of a high risk for osteoporosis, including early menopause with no HRT.⁵ Up to 35% of compression fractures in female patients over the age of 45 years may be due to early menopause.^{9,10} In the current study, 43 of the 68 respondents chose to x-ray this patient, representing a 63.24% agreement with the established gold standard. Eight of the 25 respondents who chose not to x-ray this patient explained in their rationale that they would refer this patient for a dual-energy x-ray absorptiometry (DEXA) scan. Although these respondents are included in the “no x-ray” category, they appropriately identified the risk factor for osteoporosis and chose to assess the patient’s bone density by other means, which was actually a better answer for this case. The primary tool available to chiropractors for evaluating osteoporosis is plain-film radiography. However, a bone density loss of 30% to 50% is necessary before signs of osteopenia become evident on plain films, thus the DEXA scan is a more sensitive means of measuring bone density.^{9,10}

In this case scenario, however, interns were not very accurate at selecting the appropriate views.

Only 14 interns (21%) chose a complete series with an equal number (21%) choosing an incomplete diagnostic series. Five interns (7%) chose a complete series plus additional views and seven (10%) chose an incomplete series with additional views. Two interns (3%) chose the wrong views entirely, and one intern did not choose any views at all. Obviously this area needs more emphasis in the undergraduate curriculum.

The third “yes” case in this study involved an upper limb trauma, specifically a fall on an outstretched hand. Trauma and symptoms of arthritis are the two most common indications for extremity radiographs.⁶ Distal radial fractures account for about one-sixth of all fractures seen in emergency rooms and those occurring in young adults are often due to winter sport activities.¹¹ Sixty-four of 67 respondents chose to x-ray the patient depicted in the case scenario, representing a 95.52% agreement with the gold standard. One of the respondents who chose not to x-ray the patient reasoned that the patient’s pain could be due to superficial wounds, and another respondent chose to conservatively treat the patient first. Both of these interns were not following imaging guidelines and could have harmed this patient. The third “no” respondent did not give a rationale for the decision not to x-ray.

Interestingly, the two gold standard sources did not agree on what constituted a complete diagnostic series for this case. One of the radiologists chose to include the PA wrist, PA ulnar deviation, medial oblique wrist, and lateral wrist as a complete diagnostic set. However, this radiologist also explained in his or her rationale that he or she would consider taking a PA hand and oblique hand as well, depending on the physical examination findings. The other radiologist chose the PA hand and oblique hand views as representative of a complete diagnostic series, reasoning that the wrist would be adequately visualized in these views. As a result, we chose to accept both diagnostic sets as complete. Therefore, if interns chose all views in either of the aforementioned series, we accepted their response as a complete diagnostic series. Twenty-six interns (38%) chose a complete diagnostic series, whereas 16 interns (24%) chose an incomplete diagnostic series. Another 16 interns (24%) ordered a complete diagnostic series but also had extra views. Four interns (6%) had an incomplete series with additional views, and two (3%) did not choose any views at all.

The first “no” case in this study (radiographs were not indicated according to the guidelines) involved a 40-year-old man with a recent knee trauma. The Ottawa knee rules were developed in 1996 and have been shown to reduce the number of knee radiographs taken by at least 25% without risking any harm to the patient.¹² The rules state that a knee x-ray study is only required for knee injury patients fulfilling at least one of the following criteria: 1) age 55 or older; 2) isolated tenderness of the patella (that is, no bone tenderness of the knee other than the patella); 3) tenderness at the head of the fibula; 4) inability to flex to 90°; and 5) inability to bear weight both immediately and in the emergency department (four steps; unable to transfer weight twice onto each lower limb regardless of limping).¹³ Fifty-two of the respondents chose not to x-ray the patient, representing a 76.47% agreement with the gold standard. Sixteen of the 68 respondents did choose to x-ray this patient, with the most common cited rationale being that the patient had incurred trauma to the knee. Although it may be considered prudent to x-ray trauma patients, clinical judgment should also take into account guidelines that have been published in the literature to avoid exposing patients to unnecessary ionizing radiation.

The second “no” case scenario in the study involved a 30-year-old woman presenting with mechanical low back pain and no red flag indicators for lumbar spine radiography. All 68 respondents chose not to x-ray this patient, representing a 100% agreement with the gold standard. It can be assumed that all respondents were able to correctly identify the lack of radiographic red flags in the case history and the ability of the patient’s symptoms to be reproduced via orthopedic examination.

The third “no” case involved a 45-year-old man presenting with pain and tenderness in his fifth toe following a minor trauma with no obvious swelling or edema. The Ottawa ankle and foot rules were developed in the early 1990s and it has been shown that their implementation can significantly decrease the number of unnecessary ankle radiographs by approximately 30% to 40%.¹⁴ According to these rules, an ankle radiographic series is only required following trauma if there is any pain in the malleolar zone and any of the following findings are present: 1) bone tenderness at the posterior edge or tip (within 6 cm) of the lateral malleolus, 2) bone tenderness at the posterior edge or tip (within 6 cm) of the medial malleolus, and 3) inability to bear weight both immediately and at presentation. A foot

radiographic series is only required if there is any pain in the midfoot zone and any of these findings are present: 1) bone tenderness at the base of the fifth metatarsal, 2) bone tenderness at the navicular, and 3) inability to bear weight both immediately and at presentation.¹⁵ Fifty-two of 68 respondents correctly chose not to x-ray the patient in this case, representing a 76.47% agreement with the gold standard. Three of the 16 respondents who chose to x-ray the patient misread the case and cited in their rationale that they would x-ray based on an inability to bear weight, even though the final sentence of the case stated that the patient could indeed bear weight. Six more of the respondents who chose to x-ray this patient based their decision on the fact that the patient suffered a trauma. Interestingly, seven of the 16 respondents who chose to x-ray cited the Ottawa ankle rules in their rationale. Although these respondents are cognizant of guidelines for ankle and foot radiographs, it can be assumed that they failed to distinguish between pain present in the fifth toe versus pain in the midfoot area (base of the fifth metatarsal).

The fourth “no” case dealt with a 40-year-old woman who had been involved in a minor motor vehicle accident (MVA). The Quebec Taskforce on Whiplash-Associated Disorders (WAD) has suggested the following system for classifying the severity of cervical sprains¹⁶: WAD 0—no neck pain complaints, no physical signs; WAD 1—neck pain and complaints of stiffness and tenderness only, no physical signs; WAD 2—neck complaints and musculoskeletal signs (ie, decreased range of motion and point tenderness); WAD 3—neck complaints and neurological signs (weakness, sensory and reflex changes); WAD 4—neck complaints with fracture and/or dislocation. From the clinical case, it was clear that the patient had suffered a WAD 1 injury and, according to the Quebec task force, did not require a radiological evaluation. Forty-nine of the respondents correctly chose not to x-ray this patient, representing a 72.06% agreement with the gold standard. All respondents who decided to x-ray and who gave their rationale cited trauma as the reason why they would x-ray the patient.

The fifth “no” case was actually somewhat ambiguous. It dealt with a 14-year-old female scoliosis patient who had an 18° right-sided thoracic curve that had been evaluated radiographically every 3 months for the past 2 years. The case presentation suggested that her curve was not progressing, but no information was given on skeletal maturity. Gold

standard A chose not to x-ray this patient, although it was considered a “tough decision” and it was reasoned that it would depend on the patient’s bone age and whether it was believed that the scoliosis had not progressed. Gold standard B also chose not to x-ray this patient but mentioned that the decision to continue to x-ray this patient should be determined by whether the patient had reached full skeletal maturity by looking at Risser’s sign. If this patient had not reached skeletal maturity, Gold standard B determined that PA (not AP) full-spine x-rays should be continued once every 6 months until skeletal maturity was reached. For adolescent scoliosis patients, the recommendation for curves less than 30° is observation with follow-up radiographs at regular intervals.¹⁷

It must be pointed out that should radiographs be needed to evaluate scoliosis, substituting the PA projection for the traditionally used AP view significantly reduces breast exposure and thus the cancer risk.^{18,19} Large and significant excess relative and absolute risks of breast cancer mortality have been reported among a cohort of 5,573 scoliosis patients who had frequent diagnostic x-rays during late childhood and adolescence.³ Patients underwent an average of 25 radiographs, and the mean estimated radiation dose to the breast was 10.8 cGy, using the AP projection. A statistically significant 70% excess risk of dying of breast cancer was observed compared with the general population, and patterns were consistent with radiation as a causative factor, in that risk increased with increasing number of diagnostic radiographic examinations and cumulative radiation dose to the breast.³ However, as pointed out earlier, using the PA projection rather than the AP view will greatly reduce the risk to breast tissue in scoliosis evaluation.^{18,19} The data from studies on breast cancer and radiation dose come from studies using the AP projection only. In our current study, only 8 out of 68 (12%) interns chose to x-ray this patient, while the remaining 60 respondents chose not to expose her to more radiation. The eight interns who chose to x-ray this patient all stated that their rationale was based on determining skeletal maturity and the likelihood of curve progression. Among the interns who chose not to x-ray this patient, a common rationale was that the curve was small and that the patient was most likely skeletally mature. Some interns mentioned that they would look at old x-rays, while others said that they would order x-rays in 6 months to a year.

Two cases included in this study were considered gray areas. They represented clinical scenarios where there were no concrete evidence-based guidelines or indications to help in the decision of whether or not to x-ray a patient. These two cases were confirmed as being gray areas not only by their clinical information but also by the disagreement between the two established gold standards. These cases were purposely included to reflect the realities of clinical practice.

The first “gray” case dealt with a 20-year-old hockey player who had shoulder pain after being checked into the boards. Range of motion (ROM) was restricted globally at end ranges with springy-end feels. One of the gold standards (A) chose to x-ray this patient with an AP internal shoulder rotation view and an AP baby arm view. The rationale for this choice was that the patient should be x-rayed because of the history of trauma with immediate pain and that these x-rays should be ordered before the MRI that the patient most probably required. The other gold standard (B) chose not to x-ray this patient because the patient exhibited nearly full ROM even though it was slightly restricted at the end ranges. The gold standard in this case also added that if the physical exam showed focal pain at the acromioclavicular joint, he or she would order an AP acromioclavicular view. Twenty of the 67 responses (30%) in this study chose not to x-ray this patient. The rationale provided by these interns agreed with the gold standard B in terms of ROM and acromioclavicular joint concerns. The other 47 of the 67 responses (70%) chose to order x-rays in accordance with gold standard A and based their decision on the presence of both a traumatic event and immediate pain.

The second “gray” case dealt with a 54-year-old man with neck pain that began insidiously after being involved in a car accident the year before presentation. In this case, the patient had pain on coughing and sneezing and weakness in both hands. Gold standard A chose not to x-ray this patient because the old films would be viewed first and an MRI scan would be the appropriate imaging choice based on the presenting symptoms. Gold standard B chose to x-ray this patient and cited the fact that stable fractures are sometimes not obvious on the initial x-rays taken following trauma and that these fractures may become obvious at a later date. Gold standard B also reasoned that fractures are sometimes missed in emergency rooms and that it is

not safe to rely on the patient’s given clinical information that the radiographs taken were considered to be normal. Forty-eight of the 68 responses (70%) chose to x-ray this patient in accordance with gold standard B. Most of the reasons given in favor of x-raying the patient were based on the suggestion of a space-occupying lesion and possible neurological signs. Twenty of the 68 responses (30%) chose not to x-ray this patient in accordance with gold standard A. Rationales given included obtaining the old films before x-raying the patient or referring the patient for another imaging procedure such as an MRI.

There were some limitations to this study. First, a written clinical vignette does not replace the patient–doctor interaction. There were a couple of instances in which it was clear that some interns misread critical information in the cases. In addition, there may have been certain questions or physical exam findings that interns would have wanted before they made a decision whether to x-ray a patient. Because of the already lengthy survey, it was impractical to include any more clinical information. That being said, there was sufficient evidence provided in all cases on which the interns could base their decisions. However, the cases in this study do not represent real-life situations in which a chiropractor would be able to perform a complete history and physical examination when a patient presented with a complaint. Another area not addressed in this study was medicolegal issues. In real-life situations, a chiropractor must always be cognizant that there exists a possibility of being part of a legal proceeding or being sued by a patient. This could have an effect on a chiropractor’s decision as to whether or not to radiograph the patient. Our target population, interns, have yet to be faced with those concerns. It would be a good future study to do a follow-up of the 2005 graduating class 5 years after graduating to see if experience in practice has any impact on their x-ray decision making. Another limitation, for which it is impossible to control, is whether or not the interns surveyed were honestly basing their decisions on how they will act once in practice as they were instructed. Because the survey was confidential, it can be assumed that people were accurately and honestly answering the survey as if they were in private practice. Another limitation of the current study was the sample size. Out of 130 interns surveyed, only 68 (52%) responded.

A common theme in many of the case rationales given by the interns was to x-ray every trauma patient. Although trauma is an appropriate

indicator for x-rays, clinical decision making based on evidence-based guidelines must still be considered in all cases. It is possible that an intern's decision to x-ray all trauma patients could be solely from a legal protection viewpoint.

One could argue that the two DACBRs were not really a "gold standard," particularly when they could not agree in the two ambiguous cases. Although both radiologists were very cognizant of published imaging guidelines, the two ambiguous cases highlight the fact that there are always patients in clinical practice in whom the appropriate decision as to whether or not to x-ray, as well as which particular views to take, are not clear-cut and clinical judgment must prevail. These cases, which are often referred to as "gray areas" were purposely included to reflect the fact that different clinicians may occasionally come to different, but arguably, equally valid conclusions based on the given information in a case. Imaging guidelines are not absolute rules, they are simply guidelines. Helping students and interns become more comfortable with uncertainty is part of the job of clinical educators.

There is no debate that diagnostic radiographs provide great benefits when used appropriately. However, exposure to ionizing radiation does pose dangers and risks. It has been demonstrated that the risk of cancer increases with increased exposure to ionizing radiation.

CONCLUSION

The results of this study demonstrate that one class of interns was generally aware of the radiographic guidelines outlined in the current literature and taught through the radiology program. The interns' choices as to whether or not to x-ray patients were for the most part consistent with those established by the gold standard. However, interns did not perform well in choosing which x-rays to take when compared with the gold standard. These areas need more emphasis in the curriculum.

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