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Education Improves Musculoskeletal Radiology Interpretation by Trainees in a Low-Resource Setting

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OBJECTIVE: The aims of this study were to assess baseline musculoskeletal radiology knowledge among Haitian orthopedists and to determine the impact of an adult and pediatric musculoskeletal radiology lecture series.

DESIGN: Participants were given lectures reviewing normal and abnormal elbow radiographs and received assessments before and after the intervention. Bivariate and multivariate analyses were used to identify factors associated with baseline and postintervention scores.

SETTING: This study was carried out as part of the 2018 Haitian Annual Assembly of Orthopaedic Trauma. This is an annual continuing medical educational conference in the capital city of Port-au-Prince open to all Haitian orthopedic surgeons and associated care providers, with a strong focus on resident training.

PARTICIPANTS: Haitian orthopedic surgery residents and surgeons attending the 2018 Haitian Annual Assembly of Orthopaedic Trauma.

RESULTS: Thirty-seven residents and faculty consented to participate in this study and 32 (86.5%) were male with a median age of 33 (interquartile range: 30-35). On multivariate analysis controlling for the title (resident versus attending), total years of orthopedics (beginning

of residency and beyond), and formal radiology teaching in medical school or residency, conference attendance in the past was significantly associated with higher preintervention assessment scores (odds ratio = 1.24, 95% confidence interval = 1.06-1.44, $p = 0.010$). The mean total preintervention accuracy for correctly identification of pathology, if present, was 70% compared to 83% at the postassessment ($p < 0.001$).

CONCLUSIONS: Overall, this study demonstrates that a brief lecture series at a continuing medical conference in Port-au-Prince, Haiti improved upper extremity radiographic interpretation based on pre and postassessments, and that prior conference attendance may be associated with higher baseline scores. (J Surg Ed 76:1605–1611. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

ABBREVIATIONS: CME, continuing medical education; HAAOT, Haitian Annual Assembly for Orthopaedic Trauma; MSK, musculoskeletal

KEY WORDS: Global surgery, Haiti, orthopedic surgery, radiology, residency, surgical education

COMPETENCIES: Medical Knowledge, Practice-Based Learning and Improvement, Patient Care

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Ethical statement: This study was exempted from human subjects' research review by our institutional review board.

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INTRODUCTION

Musculoskeletal (MSK) imaging is critical to orthopedic education.¹⁻⁵ The United States adopted standardized national radiology education only as recently as 2005.⁶ In contrast, low-middle income countries may suffer

from a lack of standardized MSK radiology curriculum due to a lack of resources. In resource-limited settings, MSK radiology education requires overcoming multiple challenges, including barriers to equipment utilization and maintenance, curriculum consensus, implementation, and appropriate expertise.⁷

Started in 2013, the Haitian Annual Assembly for Orthopedic Trauma (HAAOT) is a continuing medical education (CME) conference in Port-Au-Prince, Haiti held in conjunction with the Haitian Ministry of Health, the Foundation for Orthopaedic Trauma, and the SIGN Foundation.⁸⁻¹⁰ The conference consists of didactics, hands-on workshops, and research presentations primarily directed at Haitian orthopedic residents. Previous studies examining the educational efficacy of this conference demonstrate value and educational benefit to the resident education.^{9,11}

This study was conducted as part of HAAOT and the primary purpose of this study was to assess the educational impact of an integrated upper extremity radiology lecture series delivered during HAAOT 2018. The aims of this study were to assess MSK radiology baseline knowledge, and to determine the impact, if any, of the lecture series using pre- and postintervention testing.

MATERIAL AND METHODS

Settings

This study was carried out as part of the 2018 HAAOT. This is an annual continuing medical educational conference in the capital city of Port-au-Prince open to all Haitian orthopedic surgeons and associated care providers, with a strong focus on resident training. Topics are driven by local need and interest, incorporating didactic lectures, hands-on simulation workshops, and research presentations all led by both Haitian and visiting faculty.

Intervention

Participants, including Haitian residents and faculty, were given two 15-minute lectures reviewing normal and abnormal elbow digital radiographs for pediatric and adult patients. Elbow imaging and trauma has been noted previously by our group as a requested teaching topic of interest in this population. Normal radiographs were defined as radiographs with no hardware, fracture, dislocation or other obvious musculoskeletal injury. Abnormal radiographs were defined as radiographs demonstrating acute traumatic injuries (dislocation, joint injury, fractures). Lectures were delivered by 2 fellowship-trained attending surgeons in pediatric and adult orthopedic trauma surgery and included a combination of normal anatomy review as well as pathology recognition and classification.

Study of the Intervention

Participants received a preintervention assessment prior to the lecture. The pretest assessments for each trainee included 6 images drawn from a pool of 12 available images. The same 6 images were presented to each examinee. Each question was a single view of the digital radiograph. Each 6-item assessment included 6 radiographs with one arrow drawn to an anatomical structure instructing trainees to (1) describe any pathology if present, or (2) name the anatomic structure if no pathology present. Trainees were allotted 60 seconds per radiograph.

Participants received postintervention assessments after completion of both lectures. The post-test interventions for each trainee included 9 images, 3 new images and the 6 images previously used in the preassessment. Trainees were also asked to rate personal comfort with interpreting radiographs before the pre- and postintervention assessments.

Outcomes

The following outcomes measures were used to assess the impact of the intervention: (1) preintervention assessment scores (2) change in score between the pre- and postintervention assessments. Assessments were scored by giving one point per image for correct recognition of abnormal versus normal. An additional point was given for each abnormal image if a correct description of the pathology was provided; for normal images, identification of normal gained this second point. Subgroup analysis was performed based on demographic data to examine for correlation between demographic data and improved performance on the assessment.

Analysis

Descriptive statistics were generated for the study population. Bivariate statistics were generated with univariable logistic regression. Change in assessment scores was assessed with Mann-Whitney test to compare trainee performance before and after the intervention. Significance was defined at a p-value threshold $p < 0.05$. Multivariable linear regression with was used to identify factors significantly associated with improvement from pre- and postintervention assessment.

Ethical Considerations

This study was approved and exempted from prospective biomedical human subjects' research review by our institutional review board. Attendees voluntarily consented to participate in this study and were given the option to decline pre- or postassessment without foregoing the radiology lecture teaching.

RESULTS

Demographics

The basic demographic data has been summarized in [Table 1](#). Thirty-seven of the conference attendees consented to participate in this study and 32 (86.5%) were male with a median age of 33 (interquartile range: 30-35) ([Table 1](#)). Twenty-seven (73%) were residents and of these residents, 11 (42.3%) were in the fourth (final) year of residency. Among attending surgeons, $n = 10$ (27%), the majority, $n = 6$ (60%) had practiced for 3 or more years. Twenty-eight (75.7%) of participants had attended the educational conference in the past and the 29 (78.4%) worked in university hospitals. Overall, 31 (83.8%) received formal radiology teaching in medical school, 17 (45.9%) received formal radiology teaching in residency, and 15 (40.5%) reported interpreting an average of 10 or more elbow radiographs per week ([Table 2](#)).

Subjective Comfort

The preintervention subjective comfort scores indicated that 24 (64.9%) felt somewhat comfortable interpreting elbow radiographs and 9 (24.3%) felt very comfortable. In comparison, after the intervention, 19 (51.4%) felt very comfortable interpreting elbow radiographs.

TABLE 1. Baseline Characteristics of Study Population, $n = 37$

Variable	Definition	n (%)
Sex	Female	5 (13.5)
	Male	32 (86.5)
Age (years)	Median (interquartile range)	33 (30-35)
Title	Resident	27 (73.0)
	Attending	10 (27.0)
Year of residency (resident only)	1	6 (23.1)
	2	3 (11.5)
	3	6 (23.1)
	4	11 (42.3)
Years in practice (attending only)	0-2	4 (40.0)
	3 or more	6 (60.0)
Attended conference in past	No	9 (24.3)
	Yes	28 (75.7)
Place of work	District hospital	8 (21.6)
	University hospital	29 (78.4)
Hospital	HUEH	10 (27.0)
	HUJ	4 (10.8)
	HUP	15 (40.5)
	Other	8 (21.6)
Type of hospital	Mission	3 (8.1)
	Private	4 (10.8)
	Public	28 (75.7)
	Public and private	2 (5.4)

HUEH, Hopital d l'Universite d'Etat d'Haiti; HUJ, Hopital Universitaire Justilien; HUP, Hopital Universitaire La Paix.

TABLE 2. Participant Radiology Teaching History and Rating of Didactic Intervention

Variable	Definition	n (%)
Formal radiology teaching in medical school	No	6 (16.2)
	Yes	31 (83.8)
Formal radiology teaching in residency	No	20 (54.1)
	Yes	17 (45.9)
Average number of radiographs interpreted per week	1-5	14 (37.8)
	5-10	8 (21.6)
	10+	15 (40.5)
Preintervention comfort interpreting elbow radiographs	Neutral or somewhat uncomfortable	4 (10.8)
	Somewhat comfortable	24 (64.9)
	Very comfortable	9 (24.3)
Postintervention comfort interpreting elbow radiographs	Somewhat comfortable	18 (48.6)
	Very comfortable	19 (51.4)

Assessment Score Change

The mean preintervention accuracy for recognizing normal versus pathologic radiographs was 89% compared to 94% at the postassessment ($p = 0.49$) ([Table 3](#)). The mean preintervention accuracy for correctly describing pathology in abnormal radiographs improved from 52% to 72% at the postassessment ($p < 0.001$). The mean total preintervention accuracy for correctly identification of pathology, if present, was 70% compared to 83% at the postassessment ($p < 0.001$).

Preintervention Assessment Scores

Factors significantly associated with higher preintervention assessment scores on bivariate analyses were the third year of residency relative to the first year (odds ratio [OR] = 1.27, 95% confidence of interval [CI] = 1.03-1.56, $p = 0.037$) and conference attendance in the past (OR = 1.25, 95% CI = 1.10-1.41, $p = 0.00014$) ([Table 4](#)). On multivariate analysis controlling for title (resident versus attending), total years of orthopedics (beginning of residency and beyond), and formal radiology teaching in medical school or residency, conference attendance in the past significantly increased preintervention assessment scores (OR = 1.24, 95% CI = 1.06-1.44, $p = 0.010$) ([Table 5](#)).

Pre- and Postintervention Assessment Improvement

None of the measured covariates showed statistically significant association with score improvement at the postintervention assessment in comparison to preintervention test ([Table 6](#)).

TABLE 3. Pre- and Postintervention Performance, $n = 37$

Image	Definition	All	Pediatric	Adult
Normal vs. Abnormal	Preintervention	0.89	0.91	0.88
	Postintervention	0.94	0.99	0.92
	p-value	0.49	0.082	0.83
Description of pathology	Preintervention	0.52	0.84	0.36
	Postintervention	0.72	0.88	0.64
	p-value	<0.001	0.66	<0.001
Total score	Preintervention	0.70	0.87	0.62
	Postintervention	0.83	0.94	0.78
	p-value	<0.001	0.59	<0.001

TABLE 4. Bivariate Analysis of Preintervention Score, $n = 37$

Variable	Definition	Odds Ratio	95% CI	p Value
Sex	Female	Ref.	-	-
	Male	0.97	0.81-1.12	0.70
Age	Years	1.01	0.99-1.02	0.59
Title	Resident	Ref.	-	-
	Attending	1.07	0.93-1.22	0.36
Year of residency (resident only)	1	Ref.	-	-
	2	1.22	0.94-1.57	0.15
	3	1.27	1.03-1.56	0.037
	4	1.20	1.00-1.44	0.061
Attended in past	No	Ref.	-	-
	Yes	1.25	1.10-1.41	0.0014
Place of work	District hospital	Ref.	-	-
	University hospital	0.97	0.83-1.12	0.66
Formal radiology teaching in medical school	No	Ref.	-	-
	Yes	1.13	0.97-1.33	0.14
Formal radiology teaching in residency	No	Ref.	-	-
	Yes	1.04	0.92-1.18	0.50
Average number of radiographs interpreted per week	1-5	Ref.	-	-
	5-10	1.05	0.93-1.22	0.54
	10+	1.06	0.89-1.24	0.40
Preintervention comfort interpreting elbow radiographs	Neutral	Ref.	-	-
	Somewhat comfortable	0.99	0.81-1.21	0.92
	Very comfortable	1.09	0.88-1.37	0.43

CI, confidence of interval.

TABLE 5. Multivariate Analysis of Preassessment Score, $n = 37$

Variable	Definition	Odds Ratio	95% CI	p Value
Title	Resident	Ref.	-	-
	Attending	1.00	0.88-1.14	0.99
Total years of orthopedics	≤ 3	Ref.	-	-
	> 3	1.00	0.88-1.13	0.99
Attended in past	No	Ref.	-	-
	Yes	1.24	1.06-1.44	0.010
Formal radiology teaching in medical school or residency	No	Ref.	-	-
	Yes	1.11	0.96-1.29	0.18

Odds ratio greater than one indicates positive association with a higher preassessment score. CI, conflict of interest.

TABLE 6. Bivariate Analysis of Assessment Score Improvement, Preassessment Score Relative to the Postassessment Score, $n = 37$

Variable	Definition	Odds Ratio	95% CI	p Value
Sex	Female	Ref.	-	-
	Male	1.01	0.89-1.15	0.90
Age	Years	0.998	0.99-1.01	0.77
Title	Resident	Ref.	-	-
	Attending	0.96	0.87-1.06	0.43
Year of residency (resident only)	1	Ref.	-	-
	2	0.98	0.80-1.21	0.86
	3	0.98	0.82-1.16	0.79
	4	0.97	0.83-1.13	0.70
Attended in past	No	Ref.	-	-
	Yes	0.94	0.85-1.04	0.27
Place of work	District Hospital	Ref.	-	-
	University Hospital	1.03	0.93-1.15	0.56
Formal radiology teaching in medical school	No	Ref.	-	-
	Yes	1.03	0.91-1.16	0.66
Formal radiology teaching in residency	No	Ref.	-	-
	Yes	0.97	0.89-1.06	0.55
Average number of radiographs interpreted per week	1-5	Ref.	-	-
	5-10	0.98	0.89-1.09	0.75
	10+	0.92	0.81-1.03	0.15
Preintervention comfort interpreting elbow radiographs	Neutral	Ref.	-	-
	Somewhat comfortable	0.97	0.839-1.13	0.70
	Very comfortable	0.95	0.81-1.12	0.56
Postintervention comfort interpreting elbow radiographs	Somewhat comfortable	Ref.	-	-
	Very comfortable	0.95	0.87-1.04	0.28

DISCUSSION

Our work demonstrates that a brief radiology lecture program delivered as part of an education conference in a resource-constrained setting may lead to a significant improvement in participant scores on the assessment of normal and pathologic conditions in elbow radiographs, at least upon immediate testing. Although this point-in-time did not explicitly test the durability of learning, we noted that participants who attended the HAAOT CME conference in the past were more likely to have higher scores on the preassessment test even when controlled for the level of residency training, and prior formal radiology teaching in medical school or residency.

Erkonen et al. previously conducted a study to assess the effect of integrated anatomy and radiology teaching in the identification of normal anatomic structures on radiographic images by 175 first-year medical school students.¹² Students accuracy increased from 17% on the pretest to 88% on the immediate post-test and remained at 74% at a follow-up test conducted 14 to 17 months after the course. Such results have also been reported in resource-limited settings. Lehman et al. studied the effect of Breast Imaging Reporting and Data System (BI-RADS) on interpretation of mammograms by Ukrainian radiologists.¹³ Fourteen Ukrainian radiologists participated in the study and were assessed on 30 screening

mammograms before and after the training. The sensitivity, specificity, and positive predictive value of the radiologist interpretation improved from 50% to 77%, 43% to 87%, 78%, and 89%, respectively. In the United States, Lieberman et al. studied the effect of interactive in-person radiology teaching with interactive-computer assisted instruction on improvement in the medical student and radiology resident factual knowledge and visual diagnosis.¹⁴ Fifty-four medical students and 4 radiology residents participated and improved significantly from both interventions but improved more from the interactive in-person tutorial. This current study and other studies of pre- and postintervention assessments showed similar results on participant improvement.

Subgroup analysis demonstrated that year of residency and prior conference attendance were factors significantly associated with better preintervention scores. More advanced training is likely associated with increased clinical experience and more accurate radiographic interpretation, but prior conference attendance was an unexpected association with higher preintervention assessment scores. This association remained on multivariate analysis after adjusting for factors previously correlated with preintervention radiology scores (year of training, prior formal radiology teaching).¹⁴ This association between prior conference attendance and higher preintervention scores may suggest and support the

importance of CME especially in resource-limited settings. Previous years of the HAAOT conference have not explicitly included a radiology curriculum as proposed in this study but have reviewed normal and pathologic findings in upper extremity radiographs.^{8,9} Fils et al. previously demonstrated that HAAOT attendee knowledge showed short-term improvement on orthopaedic content questions delivered through an audience response system during the conference.⁹ This study extends this prior work by showing the potential beneficial effect of prior attendance on long-term knowledge retention.

There are a few limitations to this study. This study did not examine the effect of lecture series long term to assess for retention over time. Follow up studies would include submitting post-test intervention at later time points to assess its effect. In addition, given our conference attendance, our study sample was relatively small and future studies should seek to further refine these findings in large populations. Furthermore, we did not adjust for multiple testing in our statistical analyses, requiring our findings of significance to be validated with a larger sample. Finally, the duration of lecture and assessment times were restricted by the conference schedule; future studies should examine longer lecture durations to better assess the incremental benefit of longer lecture periods.

Overall, this study successfully implemented a didactic radiology series for orthopedic practitioners in a resource-constrained setting that demonstrated improvement in elbow radiographic interpretation. Furthermore, initial results suggest a significant improvement in immediate pretest intervention scores and increase in participant comfort for the interpretation of pathologic upper extremity radiographs. Future work can extend these findings to follow-up at later time points as well as implementation in multiple resource-limited settings.

CONCLUSIONS

Overall, this study demonstrates that a brief lecture series at a continuing medical conference in Port-au-Prince, Haiti improved upper extremity radiographic interpretation based on pre- and postassessments, and that prior CME conference attendance may be associated with higher preassessment scores. Further studies will need to be done to examine long-term efficacy of these interventions, implementation in varied resource-limited settings, and confirmation of findings in a larger sample size.

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