Published in final edited form as:

Int J Radiat Oncol Biol Phys. 2018 August 01; 101(5): 1039–1045. doi:10.1016/j.ijrobp.2018.04.052.

Objective Evaluation of a Didactic Curriculum for the Radiation Oncology Medical Student Clerkship

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Summary

A study was conducted to determine if a structured didactic curriculum for the medical student radiation oncology clerkship improved objective knowledge compared with clerkships not utilizing a structured curriculum. Results demonstrated improved objective knowledge postcurriculum. In addition, students receiving the curriculum scored higher at early and late time points compared with students not receiving the curriculum. These results support including a structured didactic curriculum as a standard component of a radiation oncology clerkship.

Purpose—A structured didactic radiation oncology clerkship curriculum for medical students is in use at multiple academic medical centers. Objective evidence supporting this educational approach over the traditional clerkship model is lacking. This study evaluated the curriculum efficacy using an objective knowledge assessment.

Methods and Materials—Medical students received the Radiation Oncology Education Collaborative Study Group (ROECSCG) curriculum consisting of 3 lectures (Overview of Radiation Oncology, Radiation Biology/Physics, and Practical Aspects of Simulation/Radiation Emergencies) and a radiation oncology treatment-planning workshop. A standardized 20-item multiple choice question (MCQ) knowledge assessment was completed pre- and post-curriculum and approximately 6 months after receiving the curriculum.

Results—One hundred forty-six students at 22 academic medical centers completed the ROECSCG curriculum from July to November 2016. One hundred nine students completed pre- and post-clerkship MCQ knowledge assessments (response rate 74.7%). Twenty-four students reported a prior rotation at a ROECSCG institution and were excluded from analysis. Mean assessment scores increased from pre- to post-curriculum (63.9% vs 80.2%, $P < .01$). Mean MCQ knowledge subdomain assessment scores all improved post-curriculum (t test, P values $< .01$). Post-scores for

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Conflict of interest: Dr Golden reports a financial interest in RadOncQuestions, LLC. No other authors report conflicts of interest.

Supplementary material for this article can be found at www.redjournal.org.

students rotating de novo at ROECSG institutions ($n = 30$) were higher compared with pre-scores for students with 1 prior rotations at non-ROECSG institutions ($n = 55$) (77.3% vs 68.8%, $P = .01$), with an effect size of 0.8. Students who completed rotations at ROECSG institutions continued to demonstrate a trend toward improved performance on the objective knowledge assessment at approximately 6 months after curriculum exposure (70.5% vs 65.6%, $P = .11$).

Conclusions—Objective evaluation of a structured didactic curriculum for the radiation oncology clerkship at early and late time points demonstrated significant improvement in radiation oncology knowledge. Students who completed clerkships at ROECSG institutions performed objectively better than students who completed clerkships at non-ROECSG institutions. These results support including a structured didactic curriculum as a standard component of the radiation oncology clerkship.

Introduction

Medical student clinical rotations such as internal medicine (1), surgery (2), emergency medicine (3), dermatology (4), urology (5), and palliative medicine (6) have structured didactic curricula to complement the clinical experience. In 2012 and 2013, a national survey of students applying to radiation oncology revealed that medical students complete a median of 3 clerkships at multiple institutions before applying to residency (7, 8). For each clerkship completed, students reported on curriculum experiences and self-assessed their post-clerkship knowledge and confidence in various facets of radiation oncology. The survey results demonstrated a high degree of variability in clerkship educational experiences and that the majority of clerkships had no structured didactic curricula. However, students who completed clerkships with formal didactic components reported greater self-perceived preparedness to function as radiation oncology residents (8). Radiation oncology curricula exist for the third year of medical school (9–12), and student primers are available (13). However, no structured didactic curriculum was publicly available or reported in the literature in 2012.

In response to these national survey data, a structured didactic curriculum was developed and implemented at 2 institutions in the United States (14). In a subspecialty such as radiation oncology, the yearly sample size of trainees at any single institution is too small to acquire meaningful objective results on the impact of the curriculum (15). To overcome the small number of medical students at single institutions, the multi-institutional collaborative group research model was adapted. The collaborative model has demonstrated effectiveness in other settings such as treatment of rare diseases by pooling patients from multiple institutions treated in a given time frame (16). Initially piloted at 2 institutions in 2012 (14), the curriculum was expanded to 11 institutions in 2013 (17, 18) and to 14 institutions in 2014, thus forming the Radiation Oncology Education Collaborative Study Group (ROECSG; <https://roecsg.uchicago.edu>). Upon completion of a clerkship at a participating institution, each student voluntarily and anonymously evaluated the ROECSG curriculum. Subjective evaluations from students were positive (14, 17, 18), and students who completed at least 1 clerkship at an institution that had instituted the ROECSG curriculum reported greater post-clerkship confidence in their radiation oncology knowledge and their ability to

function as a radiation oncology resident (19). However, these initial reports did not evaluate the efficacy of the curriculum using an objective measure such as a knowledge assessment.

To further increase adoption or adaptation of the structured curriculum within radiation oncology departments, objective evidence demonstrating a benefit to using the curriculum over the traditional model is needed. This study tested the hypothesis that students who complete a radiation oncology clerkship with a structured didactic curriculum demonstrate improved fundamental radiation oncology knowledge at the end of the clerkship compared with the beginning of the clerkship, greater fundamental radiation oncology knowledge compared with that of a control group not exposed to the curriculum (phase 1), and improved long-term knowledge retention of fundamental radiation oncology knowledge (phase 2), as measured by a multiple choice question (MCQ) knowledge assessment.

Methods and Materials

To test the hypothesis that students completing the curriculum demonstrate improved objective knowledge and improved knowledge compared with peers not completing the curriculum, the standardized ROECSSG curriculum (14, 17) was implemented in 2016 at 22 academic medical centers within the United States. Details of the curriculum materials and implementation process have been previously described (14, 17). Institutions were provided with the curriculum materials including slide files and the treatment planning session materials. Modification of materials for institution-specific practices was permitted, but institutions were asked to follow the general curriculum structure (3 lectures, 1 planning workshop).

Primary data collection and analysis occurred at the University of Chicago. Phase 1 pre- and post-clerkship data were obtained from participating ROECSSG member institutions. A 20-question validated MCQ knowledge assessment was used for the pre- and post-clerkship assessment. Phase 2 (long-term) knowledge assessment data were obtained electronically using the University of Chicago Research Electronic Data Capture (REDCap) server to distribute an anonymous survey as previously described (8).

The phase 1 study population consisted of students completing a radiation oncology clerkship at ROECSSG member institutions between July 1, 2016, and October 31, 2016, who voluntarily completed a pre- and post-clerkship objective MCQ knowledge assessment. The phase 1 pre- and post-knowledge assessment was obtained as a usual component of the students' clerkships. ROECSSG site directors distributed the pre-test via e-mail before or on the first day of the rotation. The objective test was in electronic format and was coded with the student's unique identification code as assigned by the ROECSSG site coordinator. The pre-assessment (<dummy_appendix>Appendix E1; available online at www.redjournal.org) included a brief survey collecting basic demographics (degree track, number of prior radiation oncology rotations, and whether the student had completed a prior rotation at another ROECSSG institution). The same MCQ assessment (<dummy_appendix>Appendix E2; available online at www.redjournal.org) was readministered by the ROECSSG site coordinator at the end of the clerkship, coded with the student's unique identification code, which allowed the study team to link pre- and post-assessments by individual in anonymized

fashion. REDCap data were anonymous, with only each ROECSSG site coordinator having access to the identification key. Thus, the study team was unable to link an individual with the objective data. Pre- and post-assessment scores were not used as a component of assessment of student clerkship performance. Optional submission of United States Medical Licensing Exam (USMLE) step 1 scores linked to anonymized subject unique identifiers was requested from ROECSSG site coordinators.

For phase 2 of the study, to assess long-term (approximately 6-month) knowledge retention, the same objective knowledge assessment was administered during the annual clerkship survey conducted since 2012 by investigators in the Department of Radiation and Cellular Oncology at the University of Chicago (<dummy_Appendix E3>; available online at www.redjournal.org) (7, 8, 19). The phase 2 long-term knowledge assessment study population included all students applying to the University of Chicago Radiation Oncology residency in the 2016 to 2017 National Resident Matching Program. These students were invited to complete an anonymous survey regarding their 2016 clerkship experiences that included the same validated objective knowledge MCQ assessment. Given the competitive nature of the radiation oncology match and small number of residency positions, we previously estimated that approximately 75% of radiation oncology applicants within the United States apply to the University of Chicago radiation oncology residency program each year (8). An initial invitation was sent via e-mail on February 24, 2017, and 2 follow-up reminder e-mails were also sent. The survey closed on March 12, 2017. Students generally complete radiation oncology clerkships in the spring, summer, or early fall prior to applying for residency. Therefore, the phase 2 MCQ assessment was obtained at approximately 6 months or more after completing radiation oncology clerkships. To improve the response rate, a \$5 coffee card was given as a survey completion incentive to each student completing the anonymous clerkship survey.

Anonymous clerkship survey data for phase 1 and 2 were collected and managed using REDCap electronic data capture tools hosted at University of Chicago (20). REDCap is a secure, web-based application designed to support data capture for research studies, providing (1) an intuitive interface for validated data entry, (2) audit trails for tracking data manipulation and export procedures, (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for importing data from external sources.

The MCQ assessment was initially developed as a draft MCQ assessment with input from multiple stakeholders including a radiation oncology residency program director, a radiation oncology medical student clerkship director, a radiation oncology resident, and a medical student. The initial assessment included 66 items testing content from the 3 curriculum lectures and planning session that make up the ROECSSG curriculum (17). The initial 66-item MCQ test was then distributed to 10 senior radiation oncology residents in various parts of the United States. Questions with a resident proportion correct of 0.9 to 1.0 were deemed to be testing knowledge basic enough to include in a post-clerkship medical student objective knowledge assessment. A total of 26 items were included in the pilot MCQ medical student assessment; these questions were then included in the 2016 clerkship survey

to obtain summary and individual item statistics within a fourth-year medical student cohort applying to radiation oncology.

Calculation of individual item statistics, option statistics, point biserial correlation, and overall test reliability was used to determine the final set of MCQs to constitute the pre- and post-assessments. The final MCQ assessment included 20 items (<dummy_Appendix E1>; available online at www.redjournal.org) blueprinted to the structured curriculum. Questions are classified as levels I to III based on difficulty and discrimination (21). There are 15 level I, 3 level II, and 2 level III MCQs.

Data were analyzed using descriptive statistics of students participating in the ROECSG clerkships based on completion of the pre-clerkship demographic survey, paired and unpaired *t* tests, Pearson's correlation coefficient, and regression analysis. Effect size was calculated using standardized mean difference: [(mean of the experimental group) – (mean of the control group)]/(standard deviation of the entire group) (22). Time since first rotation and USMLE step 1 scores were used as covariates when analyzing the matched data.

No attempt was made to link the phase 1 pre- and postassessment individual responses to the phase 2 clerkship survey objective assessment data. Rather, phase 2 means between groups (prior ROECSG curriculum yes vs no) were compared to assess overall long-term knowledge retention. A 1-tailed *t* test was used to compare means (it was assumed that the ROECSG students would score higher on the knowledge assessment).

This study was approved as exempt by the University of Chicago and University of Illinois at Chicago institutional review boards.

Results

In phase 1 of this study, 146 students at 22 academic medical centers completed the ROECSG curriculum from July 2016 through November 2016. One hundred nine students completed pre- and post-clerkship MCQ knowledge assessments (response rate 74.7%). Student characteristics are summarized in Table 1. Twenty-four students reported a prior rotation at a ROECSG institution. Subsequent data are reported for the 85 students who received the curriculum de novo. Student performance on objective assessment before and after rotations is summarized in Table 2. Mean pre- and post-curriculum assessment scores were $63.9 \pm 16.7\%$ and $80.2 \pm 13.0\%$, respectively ($P < .01$). The MCQ assessment demonstrated reasonable reliability (20 items; $\alpha = 0.66$). Subset analysis did not demonstrate a correlation between USMLE step 1 score and pre-test score ($n = 50$, $r = 0.21$, $P = .14$). Additionally, for students with prior clerkships at non-ROECSG institutions, time since first rotation did not correlate with pre-test score ($n = 55$, $r = -0.09$, $P = .51$).

Mean MCQ knowledge assessment subdomain scores pre- and post-curriculum were as follows: Overview of Radiation Oncology: $74.8 \pm 18.3\%$ versus $87.1 \pm 15.3\%$ ($P < .01$); Radiation Biology and Physics: $58.4 \pm 22.3\%$ versus $80.2 \pm 19.1\%$ ($P < .01$); Simulations and Radiation Emergencies: $63.2 \pm 21.1\%$ versus $77.4 \pm 16.1\%$ ($P < .01$); and Treatment Planning: $55.9 \pm 41.1\%$ versus $72.4 \pm 34.1\%$ ($P < .01$) (Table 2).

Post-scores for students completing their first rotation at ROECSG institutions were compared to pre-scores for students with 1 rotation at non-ROECSG institutions to investigate whether the ROECSG curriculum improves post-clerkship objective knowledge (Table 3). Post-scores for students rotating de novo at ROECSG institutions ($n = 30$) were significantly higher compared with pre-scores for students with 1 prior rotation at non-ROECSG institutions ($n = 55$), $77.3 \pm 13.3\%$ versus $68.8 \pm 15.4\%$ ($P = .01$) with an effect size of 0.8. The 24 students who completed a prior ROECSG rotation did not demonstrate significant score improvement (pre-rotation $78.5 \pm 18.0\%$ vs post-rotation $86.5 \pm 14.2\%$, $P = .10$).

On subset analysis based on training year, 6 students completed rotations as third-year medical students with a significant increase in pre- versus post-clerkship performance from $49.2 \pm 22.7\%$ to $78.3 \pm 13.7\%$ ($P = .01$). The 103 students who completed pre- and post-assessments as fourth years demonstrated a pre- versus post-clerkship increase from $68.2 \pm 17.2\%$ to $81.8 \pm 13.5\%$ ($P < .01$).

For phase 2, a total of 220 applicants to the University of Chicago/University of Illinois at Chicago radiation oncology residency program were invited to complete the 2017 annual clerkship experience survey (7, 8, 19). A total of 77 complete responses were returned for a response rate of 35.0%. Students completed a median of 3 clerkships (range 1–5). MCQ assessment scores for students completing at least 1 rotation at a ROECSG institution were $70.5 \pm 18.0\%$ compared with $65.6 \pm 16.3\%$ for students who did not complete a rotation at a ROECSG institution ($P = .11$, 1-tailed t test). Mean knowledge assessment subdomain scores with and without a ROECSG clerkship were $77.0 \pm 21.0\%$ versus $69.7 \pm 24.3\%$ ($P = .08$) for Overview of Radiation Oncology, $69.6 \pm 25.0\%$ versus $66.7 \pm 21.9\%$ ($P = .29$) for Radiation Biology and Physics, $68.9 \pm 21.7\%$ versus $62.1 \pm 17.6\%$ ($P = .07$) for Simulations and Radiation Emergencies, and $62.5 \pm 38.8\%$ versus $63.5 \pm 40.2\%$ ($P = .46$) for Treatment Planning. One student in the ROECSG group scored 20% on the MCQ assessment. Review of this student's responses indicated that the answers were chosen with the goal of completing the study to obtain the survey incentive. When this outlier score was discarded, the respective P values became significant for the overall assessment (Overview of Radiation Oncology and Simulations and Emergencies) (Table 4).

Discussion

The traditional radiation oncology medical student clerkship is an audition elective (23), with a majority of students reporting limited didactic education (7, 8, 19). Although prior studies have shown an improvement in students' subjective perceptions of preparedness for residency training (8) and subjective radiation oncology knowledge (19), this study demonstrates improved short- and long-term objective knowledge of radiation oncology topics. These results suggest that a structured didactic curriculum should be a standard component of any radiation oncology clerkship elective.

Others have reported improved student knowledge using structured didactics. A structured curriculum for the urology clerkship at a single institution demonstrated significant improvement when using core learning objectives and student-oriented didactic sessions (5).

Other groups have pursued curriculum development at the national level. The American Academy of Dermatology developed a series of online modules to complement clinical experiences during a 2-week introductory clerkship for fourth-year medical students (4). Although there was an improvement in objective knowledge, there was no control group to determine the efficacy of the curriculum over a standard clerkship. The Society for General Internal Medicine developed a Core Medicine Clerkship Curriculum Guide and surveyed clerkship directors across the United States. Although the guide was being used by a majority of clerkship directors, many reported insufficient faculty time and need for faculty development (1). Radiation oncology departments experience similar problems with limited faculty time for didactic teaching of medical students and limited faculty development. Thus, adoption of the ROECSG curriculum may help to overcome these barriers.

The finding on subset analysis that students who completed a second clerkship at a ROECSG institution did not have a significant improvement from pre- to post-clerkship assessment suggests that additional radiation oncology rotations may provide diminishing educational benefit. Many students may be using their second and third clerkships as audition electives, the drawbacks of which include reducing a student's ability to gain a broad medical education and the potentially discriminatory practice of using audition electives to select future residents (23). Radiation oncology educational leaders should consider methods that will ensure that students who pursue radiation oncology use their fourth year of medical school to gain a broad education rather than to complete multiple audition electives.

The second phase of this study demonstrated that students who complete the clerkship curriculum maintain a trend for improved objective radiation oncology knowledge. Review of individual answer sets suggests that some respondents may have completed the survey with the intention of receiving the incentive at the end without attempting to answer questions correctly, as indicated by low scores and having selected only alternating B and C answer choices. As noted previously, exclusion of 1 marked outlier from the ROECSG subset led to a significant difference between the 2 groups. Regardless, the long-term results provide additional evidence that a structured didactic curriculum should be considered as a standard component of a radiation oncology clerkship.

This study had several limitations. First, the curriculum content at each ROECSG institution is standardized but may not be identical in content. Additionally, we cannot guarantee all students at ROECSG institutions received the curriculum. The clerkship survey showed that 30% of ROECSG clerkships were reported as not having lectures at the medical student level (data not shown). This finding may be due to recall bias with some students not remembering the lectures or not identifying them as specifically at the "medical student" level. Alternatively, it is possible that some ROECSG sites are not administering the curriculum to all rotating students. Finally, some survey respondents may have completed the survey with the intention of obtaining the survey incentive and not answering correctly. This appeared to be the case with at least 1 significant outlier on the long-term MCQ assessment. Another limitation is that this objective assessment tests basic knowledge of radiation oncology. However, a major component of the curriculum is a hands-on treatment planning computer-based simulation exercise. The MCQ format is not conducive to testing

objective knowledge gained from this exercise, thereby limiting the applicability of this study's results. Lastly, due to the study design for the assessment of long-term knowledge retention, individual students' pre- and post-clerkship performance was not linked directly to an assessment of delayed knowledge. Rather, means of the groups were compared, providing a rough estimate of decay of knowledge (or lack thereof).

Overall, this study demonstrated improved objective knowledge at short-term and long-term time points when a structured curriculum for the radiation oncology clerkships was used. Radiation oncology medical student clerkship directors should implement a structured curriculum (ROECSSG or other) to provide an optimal learning environment to rotating medical students.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported in part by NIH UL1 TR000430 and the 2013 Philips Healthcare/Radiological Society of North America Education Scholar Grant. The authors also thank the University of Chicago Department of Radiation and Cellular Oncology.

References

1. Jablonover RS, Blackman DJ, Bass EB, et al. Evaluation of a national curriculum reform effort for the medicine core clerkship. *J Gen Intern Med* 2000;15:484–491. [PubMed: 10940135]
2. Wisniewski WR, Fournier KF, Ling YK, et al. A focused curriculum in surgical oncology for the third-year medical students. *J Surg Res* 2013;185:555–560. [PubMed: 23845865]
3. Tews MC, Ditz Wyte CM, Coltman M, et al. Implementing a third-year emergency medicine medical student curriculum. *J Emerg Med* 2015;48:732–743.e8. [PubMed: 25825161]
4. Cipriano SD, Dybbro E, Boscardin CK, et al. Online learning in a dermatology clerkship: Piloting the new American Academy of Dermatology Medical Student Core Curriculum. *J Am Acad Dermatol* 2013;69:267–272. [PubMed: 23683728]
5. Slaughenhaupt BL, Lester RA, Rowe JM, et al. Design, implementation and evaluation of a new core learning objectives curriculum for a urology clerkship. *J Urol* 2013;186:1417–1421.
6. Shaheen AW, Denton GD, Stratton TD, et al. End-of-life and palliative care curricula in internal medicine clerkships: A report on the presence, value, and design of curricula as rated by clerkship directors. *Acad Med J Assoc Am Med Coll* 2014;89:1168–1173.
7. Golden DW, Raleigh DR, Chmura SJ, et al. Radiation oncology fourth-year medical student clerkships: A targeted needs assessment. *Int J Radiat Oncol Biol Phys* 2013;85:296–297.
8. Jagadeesan VS, Raleigh DR, Koshy M, et al. A national radiation oncology medical student clerkship survey: Didactic curricular components increase confidence in clinical competency. *Int J Radiat Oncol Biol Phys* 2014;88:51–56.
9. Hirsch AE, Singh D, Ozonoff A, et al. Educating medical students about radiation oncology: Initial results of the oncology education initiative. *J Am Coll Radiol (JACR)* 2007;4:711–715. [PubMed: 17903756]
10. Hirsch AE, Mulleady Bishop P, Dad L, et al. An increase in medical student knowledge of radiation oncology: A pre-post examination analysis of the oncology education initiative. *Int J Radiat Oncol Biol Phys* 2009;73:1003–1008; quiz 1008.e1–1008.e2. [PubMed: 19251088]
11. Hirsch AE, Handal R, Daniels J, et al. Quantitatively and qualitatively augmenting medical student knowledge of oncology and radiation oncology: An update on the impact of the oncology education initiative. *J Am Coll Radiol* 2012;9:115–120. [PubMed: 22305697]

12. Zaorsky NG, Malatesta TM, Den RB, et al. Assessing the value of an optional radiation oncology clinical rotation during the core clerkships in medical school. *Int J Radiat Oncol Biol Phys* 2012;83: e465–e469. [PubMed: 22704704]
13. Berman AT, Plastaras JP, Vapiwala N. Radiation oncology: A primer for medical students. *J Cancer Educ Off J Am Assoc Cancer Educ* 2013;28:547–553.
14. Golden DW, Spektor A, Rudra S, et al. Radiation oncology medical student clerkship: Implementation and evaluation of a bi-institutional pilot curriculum. *Int J Radiat Oncol Biol Phys* 2014;88:45–50. [PubMed: 24331650]
15. Curriculum Development for Medical Education: A Six-Step Approach. In: Thomas PA, Kern DE, Hughes MT, Chen BY, editors. 3rd edition. Baltimore: Johns Hopkins University Press; 2015.
16. Timmerman R, Paulus R, Galvin J, et al. Stereotactic body radiation therapy for inoperable early stage lung cancer. *JAMA* 2010; 303:1070–1076. [PubMed: 20233825]
17. Radiation Oncology Education Collaborative Study Group, Radiation Oncology Education Collaborative Study Group Writing Committee, et al. Multi-Institutional Implementation and Evaluation of a Curriculum for the Medical Student Clerkship in Radiation Oncology. *J Am Coll Radiol* 2016;13:203–209. [PubMed: 26410347]
18. Ye JC, Mohindra P, Spektor A, et al. Medical student perspectives on a multi-institutional clerkship curriculum: A report from the radiation oncology education collaborative study group. *Int J Radiat Oncol Biol Phys* 2015;92:217–219. [PubMed: 25968822]
19. Oskvarek JJ, Brower JV, Mohindra P, et al. Educational impact of a structured radiation oncology clerkship curriculum: An interinstitutional comparison. *J Am Coll Radiol* 2017;14:96–102. [PubMed: 27652570]
20. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–381. [PubMed: 18929686]
21. Haladyna TM. Developing and Validating Multiple-Choice Test Items. 3rd edition. New York and Oxford: Routledge; 2004.
22. Cohen J Statistical Power Analysis for the Behavioral Sciences. 2nd edition. New York and Oxford: Routledge; 1988.
23. Halperin EC. The audition elective. *Int J Radiat Oncol Biol Phys* 1988;15:791–792. [PubMed: 3417496]

Table 1

The demographics of participating students

Overall	n = 109
Number of prior rotations	
0	30 (28%)
1	36 (33%)
2	35 (32%)
3	7 (6%)
4	1 (1%)
Degree	
MD	80 (73%)
DO	2 (2%)
MD, PhD	23 (21%)
Other	4 (4%)
Year in medical school	
Third	6 (6%)
Fourth	103 (94%)

Table 2

Student performance on objective assessments before and after rotations

	n	Pre-rotation assessment score Mean ± SD	Post-rotation assessment score Mean ± SD	t test P value
Overall (20 MCQs)	85	63.9 ± 16.7%	80.2 ± 13.0%	<.01
Overview talk (5 MCQs)	-	74.8 ± 18.3%	87.1 ± 15.3%	<.01
Radiation biology/physics (6 MCQs)	-	58.4 ± 22.3%	80.2 ± 19.1%	<.01
Simulations and emergencies (7 MCQs)	-	63.2 ± 21.1%	77.4 ± 16.1%	<.01
Treatment planning (2 MCQs)	-	55.9 ± 41.1%	72.4 ± 34.1%	<.01
No prior rotation	30	55.0 ± 15.6%	77.3 ± 13.3%	<.01
Prior rotation at non-ROECSG site	55	68.8 ± 15.4%	81.7 ± 12.6%	<.01
Prior rotation at ROECSG site	24	78.5 ± 18.0%	86.5 ± 14.2%	.10

Abbreviations: MCQs = multiple choice questions; ROECSG = Radiation Oncology Education Collaborative Study Group; SD = standard deviation.

Table 3

Comparison of post-assessment scores for students who completed a ROECSC clerkship as their first rotation versus students who had completed 1 prior non-ROECSC clerkship

MCQ assessment section (number of questions)	Post-clerkship; no prior rotation (ROECSC = first rotation) n = 30	Pre-clerkship; prior non-ROECSC clerkship(s) n = 55	t test P value	Effect size
Overall (20)	77.3 ± 13.3%	68.8 ± 15.4%	.01	0.8
Overview talk (5)	85.3 ± 14.8%	77.8 ± 16.2%	.04	0.5
Radiation biology/physics (6)	75.5 ± 22.6%	63.3 ± 20.8%	.01	0.6
Simulations and emergencies (7)	75.0 ± 15.4%	67.5 ± 20.8%	.10	0.4
Treatment planning (2)	71.7 ± 31.3%	67.3 ± 37.5%	.58	0.1

Abbreviations: MCQ = multiple choice question; ROECSC = Radiation Oncology Education Collaborative Study Group.

Table 4

Assessment scores for the phase 2 long-term assessment divided by students who did or did not complete any ROECSG clerkship

MCQ assessment section (number of questions)	ROECSG students n = 39*	Non-ROECSG students n = 37	t test (1-tail) P value	Effect size
Overall (20)	71.8 ± 16.3%	65.6 ± 16.3%	.05	0.4
Overview talk (5)	78.5 ± 19.1%	69.7 ± 24.3%	.04	0.4
Radiation biology/physics (6)	70.5 ± 24.6%	66.7 ± 21.9%	.24	0.2
Simulations and emergencies (7)	70.3 ± 20.0%	62.1 ± 17.6%	.03	0.5
Treatment planning (2)	64.1 ± 38.0%	63.5 ± 40.2%	.47	0.0

Abbreviations: MCQ = multiple choice question; ROECSG = Radiation Oncology Education Collaborative Study Group.

*. Single outlier excluded.