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Fostering Radiation Oncology Physician Scientist Trainees Within a Diverse Workforce: The Radiation Oncology Research Scholar Track

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There is a need to foster future generations of radiation oncology physician scientists, but the number of radiation oncologists with sufficient education, training, and funding to make transformative discoveries is relatively small. A large number of MD/PhD graduates have entered he field of radiation oncology over the past 2 decades, but this has not led to a significant cohort of externally funded physician scientists. Because radiation oncologists leading independent research labs have the potential to make transformative discoveries that advance our field and positively affect patients with cancer, we created the Duke Radiation Oncology Research Scholar (RORS) Program. In crafting this program, we sought to eliminate barriers preventing radiation oncology trainees from becoming independent physician scientists. The RORS program integrates the existing American Board of Radiology Holman Pathway with a 2-year post-graduate medical education instructor position with 80% research effort at the same institution. We use a separate match for RORS and traditional residency pathways, which we hope will increase the diversity of our residency program. Since the inception of the RORS program, we have matched 2 trainees into our program. We encourage other radiation oncology residency programs at peer institutions to consider this training pathway as a means to foster the development of independent physician scientists and a diverse workforce in radiation oncology.

Since Roentgen's transformative discovery of the x-ray in 1895 and the advent of radiation as an effective cancer treatment, scientists have studied the effects of radiation on tumors and normal organs. Important discoveries have included elucidation of the fundamental principles of cancer biology used today by oncologists of all specialties,[1]

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such as the discovery of key components of the DNA damage response pathway[2] and enhanced understanding of the biology of stem cells.[3] Recent contributions of radiation oncology physician scientists (ROPS) using powerful new tools such as CRISPR/Cas9 and genome sequencing techniques[4] have not only generated transdisciplinary cancer biology discoveries,[5] but have also elucidated foundational diagnostic[6] and therapeutic[7] concepts tested in clinical trials (NCT03696355). Although these discoveries provide opportunities for commercialization, more importantly they have the potential to improve outcomes for patients with cancer.

The need to foster future generations of ROPS has been well recognized,[8] and it is clear that the number of radiation oncologists with sufficient education, training, and funding to make transformative discoveries is small. However, the sizable number of MD/PhD graduates entering the field of radiation oncology over the past 2 decades has not led to a large cohort of externally funded physician scientists. In 2016, only 1.6% of all National Institutes of Health (NIH) cancer research funding was awarded to investigators in radiation oncology,[9] and only 0.4% (292 out of 72,304 awards) from the NIH, Food and Drug Administration, and Veterans Affairs included a radiation-related topic. Furthermore, only 11 NIH career development grants (9 K and 2 K99/R00) were awarded to radiation oncology investigators in 2016.[10] Explanations for the attrition of MD/PhD radiation oncology residents from an independent, externally funded laboratory research career path are likely multifactorial.[11] We hypothesize that an important factor is an inadequate training structure that does not provide continued mentored research when trainees complete residency.[10]

Previous efforts to enhance scholarship in radiation oncology have included the adoption of a year dedicated to research within many residency programs.[12] However, for many trainees, 1 year is insufficient to acquire the skills and knowledge to become a successful independent investigator and compete for external grants with trainees from other specialties or with PhD scientists.[13] Additionally, in most radiation oncology residency programs, there is no defined pathway to scientific independence. This differs from other medical specialties such as internal medicine and pediatrics, where specific pathways exist allowing for compressed residency and fellowship training while maintaining board eligibility, with additional structured mentored research time to develop the skills needed to become successful independent investigators.[14]

Noting the importance of dedicated research time to foster the academic careers of physician scientists within the specialties of radiation oncology and radiology, the American Board of Radiology (ABR) created the ABR Holman Research Pathway, which allows selected residents the opportunity to increase scholarly time to 21 months during residency.[15] Although this pathway was a good first step to further support career physician scientists within radiation oncology, the outcome has been somewhat disappointing; relatively few[16] have completed this program, only two-thirds remain in academic medicine, and the majority have not been successful in establishing externally funded independent research programs.[15] Two of us (S.R.F. and D.G.K.[17]) completed the Holman Research Pathway and judged that 21 months of research time was insufficient to complete postdoctoral training, publish study results in peer-reviewed journals, and acquire the skills and knowledge to start our independent research labs. Impactful science often requires a significant period of time to generate and analyze new data and complete peer review, which may take substantially longer than 21 months. Our experiences were consistent with the fact that biomedical postdoctoral training averages greater than 48 months in the United States.[13] Therefore, we spent 2 or more additional years after residency in mentored research positions before transitioning to positions as independent investigators.

Because we believe that radiation oncologists leading independent research labs have the potential to make transformative discoveries and we saw no formal structure for development, we created the Duke Radiation Oncology Research Scholar (RORS) Program. The RORS program integrates the existing ABR Holman Pathway with a 2-year post-graduate medical education instructor position at the same institution, with 80% research effort. Therefore, the RORS program provides the clinically proficient trainee 45 months of continuous time for mentored research (Fig. 1). We anticipate that this period of time will permit trainees to generate high-quality and reproducible data, publish manuscripts, successfully compete for early career development awards, and transition to scientific independence.

Our RORS program has been further strengthened by the recent award of a $1.4 million R38 grant from the National Cancer Institute that provides 80% salary support for trainees in their research block during residency, $20,000 for research expenses per trainee, and $2000 for travel to a research conference. We anticipate this grant will defray some expense in supporting physician scientist research during residency. The RORS program aligns with an institutional strategy to develop physician scientists through the Duke Office of Physician Scientist Development, which provides RORS trainees further mentorship, training, and support from across the institution. RORS trainees also have the opportunity to apply for technician support through the Office of Physician Scientist Development upon return to the clinic. Additionally, R38 awardees have the opportunity to apply for K38 training grants that provide salary support for 2 years after residency as a bridge to other career development awards, such as a K08 grant.

In crafting the RORS program, we sought to eliminate some of the barriers preventing radiation oncology trainees from becoming independent physician scientists while maintaining the strength of our traditional residency program. To accomplish this, in 2 successive years, we applied to the Accreditation Council for Graduate Medical

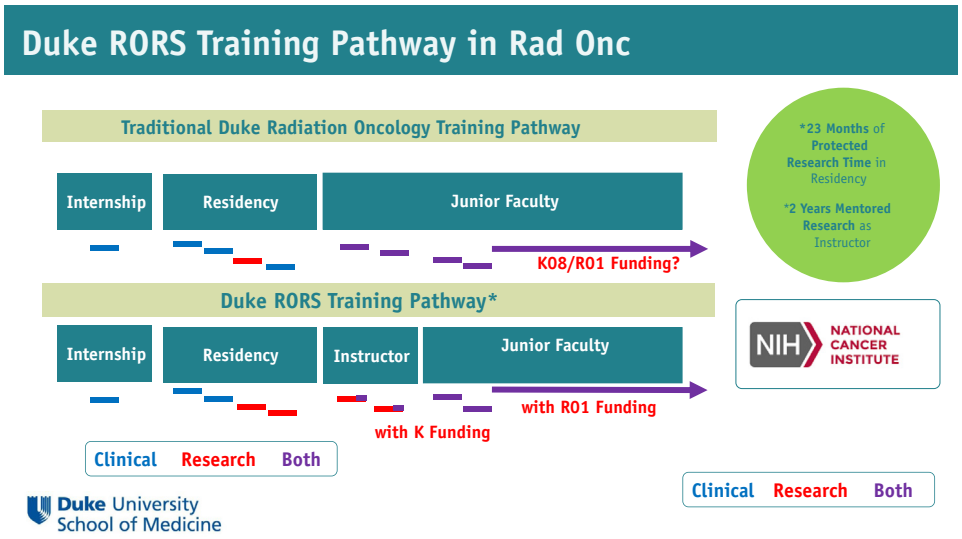

Fig. 1. Schematic comparing the traditional Duke residency pathway with 1 year dedicated to scholarly activity and the Radiation Oncology Research Scholar (RORS) training pathway with 2 years of research during residency and an additional 2 years of mentored research available after residency. Each bar represents 1 year.

Education and were granted approval to increase our resident complement by 1 spot each year, and our total resident complement now stands at 14 (from 12). Our department financially committed to support these additional residency positions before the R38 award. We encouraged all applicants to our residency who might be interested in the RORS program to complete a secondary application, focusing on prior research accomplishments and future career plans. After application review by our faculty, well-qualified candidates for the RORS program were selected to interview through our traditional process and also spend a second day with us, where they presented their scholarly efforts to date and met with potential research mentors. We subsequently ranked candidates for the RORS program in a separate match, with a separate rank list from our traditional radiation oncology residency track match.

We realize that there may be additional barriers in the development of trainees into independent ROPS, leading to attrition of trainees, including inadequate curriculum and infrastructure, inadequate mentorship, lack of funding, and inadequate institutional support.[18] Furthermore, when ROPS trainees transition to become faculty they can have increasing clinical demands and increasing administrative roles that can affect scientific productivity. We hope that the protected and mentored research structure of the RORS program will limit these challenges. We acknowledge that we are fortunate to have a strong core of physician scientists to serve as RORS mentors within our department and at our institution. We hope other institutions with outstanding physician scientists who can serve as RORS mentors will consider this approach. Additionally, we hope that as trainees from these programs make significant progress, RORS-like programs will continue to be awarded additional funding from National Cancer Institute and other national societies.

To our knowledge, the RORS program is unique as a radiation oncology-specific physician scientist training program. It provides 2 years of additional scientific training post-graduate medical education as well as selection of candidates at the time of residency matching. Other physician scientist training programs, such as at Washington University in St Louis,[19] also allow radiation oncologists to undertake an extended period of mentored research. Another alternative to the RORS program for trainees who need additional time after residency for mentored research training is to complete the Holman pathway during residency at 1 institution and then undertake a research fellowship, such as those offered at Memorial Sloan Kettering[20] and the University of Wisconsin.[21] However, by providing a time horizon of 45 months for mentored research at a single institution, RORS trainees will be able to undertake ambitious long-term research projects in an efficient manner because they will not need to transition to a new institution and identify a new project with a new mentor.

Although fostering research careers is important to the future of our field, it is certainly not the only consideration in selecting radiation oncology trainees. In fact, documented barriers and biases in Science Technology Engineering and Mathematics training[22-24] coupled with an emphasis on research credentials in the selection of trainees may contribute to disparities in radiation oncology residency programs and in our field's physician workforce.[25-27] Such biases include prioritizing medical students who have completed PhD programs or have engaged in extensive research. Because this cohort may include fewer underrepresented in medicine (URiM) and female medical students owing to historical and current barriers and biases in Science Technology Engineering and Mathematics training,[22-24] this focus on research training and

accomplishments may contribute to imbalances in trainee selection. The RORS program should help rectify these imbalances in 2 ways. First, we anticipate the RORS program, with a focus on recruiting women and URiM candidates, coupled with institutional[28] and governmental support can serve as a mechanism to support and mentor URiM students and women who have the drive and dedication to become ROPS, but may otherwise not have a clear pathway to success. Second, by using a separate match for the RORS program, we emphasize research excellence and the commitment and potential to become a physician scientist when evaluating potential for success as resident physicians and as faculty members. Equally important, the separate match allows our traditional program to take a holistic approach where research success is one of many life experiences contributing to the development of a practicing physician that we consider in evaluating candidates.

Since the inception of the RORS program, we have matched 2 trainees into our program. We believe that both our RORS and traditional tracks are complementary and will enhance the overall education and experience of all of our residents. We encourage other radiation oncology residency programs at peer institutions to consider this training pathway as a means to foster the development of independent physician scientists in radiation oncology. Through research-intensive residency pathways, radiation oncology as a field can maximize the likelihood of training the next generation of physician scientists, who can successfully lead externally funded research programs and make discoveries that advance the prevention, detection, and treatment of cancer.

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