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From novice to Expert: Reducing Breast Imaging rejection rates through physician mentorship in Advanced Practice Radiation therapy

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ABSTRACT

Purpose: The study's goal was to evaluate the impact of a Radiation Oncologist (RO)—Radiation Therapist (RTT) mentorship on image approval rates for a breast population undergoing radiation therapy in a high-volume practice. The mentorship was undertaken within a large health system in partial fulfillment of the Expert Practice Module for a Masters (MSc) in Advanced Practice Radiotherapy and Oncology.
Methods: Images were retrieved from the MOSAIQ EMR on breast diagnostic code. 1,295 images/115 patients were reviewed pre-mentorship (October 2019-March 2020) and compared with 1,047 images/91patients during/post-mentorship (April 2020-September 2020). The Anderson-Gill (AG) model was used to estimate the hazard ratio for image rejection. Rejected images were classified by reason and compared using Fisher's exact test. Concordance data (RO/RTT image rejection) were collected during Phase Three of the mentorship.
Results: Of 115 patients assessed pre-mentorship, 16 (14 %) had at least 1 image rejected at any session. Of 91 patients assessed post-mentorship, 8 (9 %) had at least 1 image rejected. Likelihood of image rejection decreased by 54 %, with a hazard ratio of 0.46 [95 % CI: 0.24, 0.88]; $p = 0.0195$. Reasons for image rejection differed pre- and post-mentorship. Poor imaging technique accounted for rejection of 9 of 24 images (37.5 %) before compared to 0 of 11 images (0 %) post-mentorship. Other reasons for image rejection: depth at isocenter (25 % pre-mentorship; 18 % post-mentorship), supraclavicular medial border position (12.5 % vs. 9.09 %), isocenter location (12.5 % vs. 0 %), arm position (4.17 % vs. 54.55 %); hip alignment (8.33 % vs. 18.18 %). Concordance rate was 100 %.
Conclusions: The mentorship proved successful in elevating the RTT's skills and image approval rates, while contributing to improvements in departmental imaging best practices.

Introduction

Mentorship during medical education and training is understood to have a positive impact on choice of specialty, professional development, career success, job satisfaction, and research productivity [1,2,3]. In the United States (U.S.), mentorship in radiation oncology has traditionally involved the mentoring of residents, research fellows, and junior faculty by senior faculty [4]. This study represents a departure from the MD-to-MD model and introduces an innovative approach employed for some time outside of the U.S. as a component of Advanced Practice Radiation Therapy (APRT) programs, mentorship engaging a Radiation Oncologist (RO) and a Radiation Therapist (RTT) [5,6,7,8]. The mentorship was undertaken in partial fulfillment of the "Expert Practice Model" for the Radiation Therapist's Masters of Science (MSc) in Advanced Clinical Practice in Radiotherapy and Oncology (ACPR), a module designed to support the transition to expert in a clearly defined scope of practice. Mentoring was intended to increase the RTT's knowledge and skill in image review in a breast population undergoing radiation therapy. The mentee (RTT) completed MSc coursework at a renowned institution outside of the U.S., with the mentorship undertaken at a large urban

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health system in the U.S. where both mentor and mentee are employed.

While the APRT level of practice is an integral component of the radiation oncology service model internationally, the APRT role is new to the U.S. [9,10]. The Advanced Practice Radiation Therapist (APRT) is expected to demonstrate expert clinical and technical knowledge, the ability to work autonomously, and the capacity and initiative to take on a leadership role in the development of new radiation therapy services [9,11]. The APRT role is shown to have benefits for multiple stakeholders, most significantly for patients. APRTs can serve as members of multidisciplinary teams to improve the coordination of care while freeing ROs to practice at the highest levels of clinical care and complexity in their efforts to maximize patient safety, while achieving the best possible outcomes and more cost-effective service; reduce gaps in care and bottlenecks; and help meet the increasing demand for radiation oncology services, particularly in the context of rapid technological and treatment advances and the increasing complexity of clinical decision making [9,12,13,14]. Through closely supervised and supportive mentorship, the RTT develops expertise in a specific scope of practice (e.g., image review) and may also find opportunities to contribute to departmental service improvements, education/training initiatives, and to the field of RO more broadly through engagement in research. The APRT role offers an opportunity for clinical career advancement and meaningful participation as members of multidisciplinary teams. This paper describes an RO/RTT mentorship designed to fulfill requirements for the Master's of Science degree in Advanced Clinical Practice in Radiotherapy and Oncology (ACPR) with the goal of enhancing expertise in breast image review. We demonstrate how clinical advancement in the RTT's scope of practice can improve accuracy in image review and imaging protocols, while also contributing to departmental inefficiencies and best practices Table 1

Methods

Clinical setting and breast imaging schedule

*T*he study was conducted in the Department of Radiation Oncology in a large academic health system. The Department has 13 full-time ROs, 11 residents who rotate through four other hospital sites, and 23 RTTs. The Department treats 132.6 patients on average daily (15 %/19.8 patients are breast imaging patients), employing a KV imaging system. All patients receive verification films; approximately 70 % meet the current departmental policy regarding signing for images on verification day: residents are authorized to sign for the first treatment for any cases with a prescribed dose of < 4 Gy after which the RTT can administer treatment; an attending physician must sign before the second treatment. Any patient receiving a dose of > 4 Gy requires attending approval of verification imaging prior to treatment.

Study period and image review

We conducted a study looking at rejection rates for all breast images for patients under the care of a single RO (mentor) during two time periods: 1,295 images/115 individual patients were reviewed prior to the mentorship (October 2019-March 2020) and compared with 1,047 images/91 individual patients during/post-mentorship period (April 2020-September 2020). The mentorship took place between April 2020-July 2020. Images were retrieved from the Department of Radiation Oncology's electronic medical record (EMR), MOSAIQ (EMR Systems, New York, NY) based on breast diagnosis code. No demographic information (e.g., age, sex/gender, race, ethnicity) was included in the selection of images to be reviewed. Image field arrangements included supine breast tangents, supine breast tangents with supraclavicular field (3-field) and prone tangential fields. Approved images were those found to be in alignment. Rejected images were found by the RO to be out of alignment. Rejected images were classified based on the reason for rejection: poor imaging technique; arm, hip, or clavicle malalignment, isocenter off laterally; depth off; superior/inferior malalignment. In Phase Two of the mentorship, the RTT studied retrospective images reviewed by the RO prior to the mentorship. The RO and RTT subsequently discussed decision-making around approval/rejection and related aspects of the review process. For the purposes of education/training, in the third phase of the mentorship, the RO permitted the RTT to independently study the first-day verification images of five new patients prior to her own review and to make an assessment (approve/reject). Following the RO's review of the images, mentor and mentee discussed each case.

Concordance data

Concordance data (RO-RTT image approval/rejection) were collected for the third phase of the mentoring intervention and was calculated at 100%. [15,16].

Mentoring intervention

The mentorship was grounded in Benner's Novice to Expert Framework, which describes the acquisition of learning new knowledge and skills over time across five stages [17,18]. Briefly, these stages describe clinical competence as: 1) novice (limited experience); 2) advanced beginner (possesses knowledge and how-to, but not in-depth experience); 3) competent (some mastery); 4) proficient (seeing the "whole" rather than the parts, able to modify plans); 5) expert (deep knowledge and experience). Having worked as a competent RTT for a number of years, but lacking in-depth experience of image review, the mentee embarked on the mentorship at Stage Two. The mentorship focused on intensive study of 12 clinical cases selected by the RO. The RO and RTT met bi-monthly over a three-month period with additional ad hoc informational consultation, as needed. Mentorship activities integrated three competency phases, with four cases completed for each phase of competency:

Phase 1: Direction Supervision: The RTT reviewed 12 clinical cases with the RO to develop greater understanding of decision making around treatment planning and radiation prescription as informed by a patient's clinical history and anatomy. Discussion topics included: importance of the location and size of gross tumor volume (GTV) within the breast; nodal involvement; inclusion of the internal mammary nodes (IMNS) and how they affect the field edge, beam arrangement, and prescribed radiation dose/fractionation. The RO shared the nuances of clinical decisions based on tumor histology and biology, breast surgical techniques, ASTRO guidelines, and extensive personal clinical experience. The RTT reviewed each treatment plan with a medical physicist/ dosimetrist to learn how the RO's decisions were incorporated into the customized design of these plans (e.g. field planning technique: weighting radiation beams to ensure appropriate dose coverage and

Table 1
Image rejection rates for Breast images pre and post mentorship.

	# Patients with Images Rejected/Total	# Images Rejected/ # Sessions	Hazard Ratio **(95 % CI)**	P-value
Post-Mentorship	8/91 (9 %)	11/509 (2 %)	0.46 [0.24–0.88]	**0.0195** *
Pre-Mentorship	16/115 (14 %)	24/549 (4 %)	Reference	

* $p < 0.05$

dose homogeneity, using dual energies for larger patient separations, etc.). In this phase, the RTT moved between stages 2–3 in Benner's framework, achieving greater mastery in the review of images based on new understanding of treatment plan design.

Phase 2: Autonomous Retrospective Review: The mentor provided training and education on the mechanics of image retrieval and review using the Review Tool in the MOSAIQ EMR, ensuring that the RO and RTT would review precisely the same images under the same conditions. The RTT then studied images that had been reviewed by the RO prior to the mentorship. Discussion topics included how decision making is informed by a patient's specific clinical needs (e.g., selection of filters for review of bone, tissue, chest wall); common causes of image rejection (e.g. incorrect positioning of the shoulder and supraclavicular region in 3-field breast treatment plans) [18,19,20]; and the nuances of setup and beam arrangements. In this phase, the RTT moved between stages 4–5, having achieved a more holistic view of patients' distinctive clinical needs as they influence setup.

Phase 3: Independent Practice. The RTT studied first-day verification images independently from a clinical perspective (i.e., applying learning from Phases One and Two) prior to the RO's review. Because the RTT did not yet have the role of APRT (assumed upon completion of the MSc degree), images were accessed in the EMR by the RO. By the completion of this phase, the RTT had achieved stage 5, demonstrating an expert level of competency, an intuitive grasp of challenges or problems, and initiating solutions to address them.

Results

A total of 1,295 images (approved, rejected) for 115 individual patients were reviewed in the pre-mentorship period and subsequently compared with a total of 1,047 images (approved, rejected) for 91 individual patients in the post mentorship period. Of 115 patients assessed pre-mentorship, 16 (14 %) had at least 1 image rejected at any session. Of 91 patients assessed post-mentorship, 8 (9 %) had at least 1 image rejected. Likelihood of image rejection decreased by 54 %, with a hazard ratio of 0.46 [95 % CI: 0.24, 0.88]; p = 0.0195. Table 1 Reasons for image rejection differed pre- and post-mentorship. Rejected images were classified based on the reason for rejection: poor imaging technique; arm, hip, or supraclavicular position or alignment; isocenter off laterally; depth off; superior/inferior alignment off. Table 2 Poor imaging technique accounted for rejection of 9 of 24 images (37.5 %) pre compared to 0 of 11 images (0 %) post-mentorship. Other reasons for image rejection: depth at isocenter (25 % pre-mentorship; 18 % post-mentorship), depth at superior border of field edge (12.5 % vs. 9.09 %), isocenter location (12.5 % vs. 0 %), arm position (4.17 % vs. 54.55 %), a finding that was subsequently investigated and addressed by the RTT, and hip alignment (8.33 % vs. 18.18 %). (Fig 1) Concordance data (RO/RTT) were collected for the third phase of the mentorship, with 100 % concordance in the assessment of approval/rejection.

Our statistical model accounted for recurrent image rejections. To estimate the relative risk of image rejection in the pre- vs. post-mentorship periods, the Anderson-Gill (AG) model, an extension of the Cox proportional hazards model, was used. In the AG model, a subject with multiple rejected images was treated as multiple subjects for analytical purposes using a counting process approach. Subjects were censored at the time of the last radiation session that did not result in an image rejection. The Lin and Wei robust sandwich variance estimator was applied to adjust the standard error, accounting for the correlation among multiple image rejections per subject. (See Fig 1). The reasons for image rejection were explored, classified, and compared between the pre- and post-mentorship periods using Fisher's exact test. All statistical analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

Table 2
Image rejection reasoning from Radiation Oncologist

Reason for Image Rejection	Images Rejected During Pre-Mentorship PeriodN = 24	Images Rejected During Post-Mentorship Period N = 11	Fisher's Exact p-value
arm position	1 (4.17 %)	6 (54.55 %)	0.0028
depth off at sup border s-i level	3 (12.50 %)	1 (9.09 %)	
Iso center depth offinf-hip pullneeded/ depth-lateral hip/ iso inf plus hip pulled to left	2 (8.33 %)	2 (18.18 %)	
isocenter depth off/	6 (25.00 %)	2 (18.18 %)	
Isocenter off right to left – laterally	3 (12.50 %)	0 (0 %)	
poor imaging technique	9 (37.50 %)	0 (0 %)	
Total	24	11	

Discussion

As a component of the MSc in Advanced Clinical Practice in Radiotherapy and Oncology, the RTT sought to develop expert competency in breast image review through the completion of three tailored phases of mentoring. Each phase incorporated education, dialogue, and collaboration. The mentee was not, theoretically, a novice, having worked as a RTT in the same high-volume RO department where the mentorship took place, and having for some time been the clinic supervisor responsible for daily operations. Nevertheless, she found herself at Stage 2 in terms of possessing a holistic view of breast radiation treatment and in-depth experience of image review. As shown in Fig 1 Fig 2., mentoring and enhanced education led to more confident and skilled image review by the RTT during verification with a 54 % reduction in rejection rates post-intervention. While prior to the mentorship, poor imaging technique accounted for rejection of 37.7 % of images (9 of 24), post-mentorship no images (0 %/9 of 11) were rejected due to poor imaging technique. Upon successful completion of the mentorship and subsequent awarding of the MSc degree, the mentee became the first radiation therapy professional in the U.S. to hold an advanced practice role.

Currently in our Department, a resident or the attending physician reviews the verification films and must approve the images before the first treatment is delivered (attending only can approve images for doses > 4 Gy). If rejected, the patient is then re-imaged resulting in longer time on the treatment table, higher radiation dose exposure, and increased patient discomfort which can lead to shifts and inaccuracies in setup and imaging. Re-imaging can also create bottlenecks and workflow disruptions. Reducing image rejection rates is critical both to optimize clinical outcomes and improve patient experience.

Our study is aligned with the literature describing mentorship to support the RTT to APRT transition outside of the U.S.: expert training and supervision by an experienced RO to improve skill in image review; developing an expert level of competency performing tasks that might have otherwise been performed by an MD; advancing a multidisciplinary model of care; understanding of the APRT role as an opportunity for clinical career advancement [5,6,12,13]. Our study has had a significant, unanticipated impact beyond the specific scope of practice around which the mentorship was designed, reinforcing the importance and potential of the APRT role. During each mentorship phase, enhancement in knowledge and skill in image review was accompanied by insight into challenges around processes, procedures, and/or practices associated indirectly or directly with the delivery of care, leading to improvements at the departmental and organizational level.

Based on the knowledge gained during the first phase of the mentorship, the RTT suggested an update to workflows to improve setup accuracy. Prior to simulation, the RTT and RO review and discuss a patient's history, consider GTV and location, nodal involvement, disease staging, and radiation dose/fractionation planned. This process leads to more informed and optimal patient positioning at simulation, with less

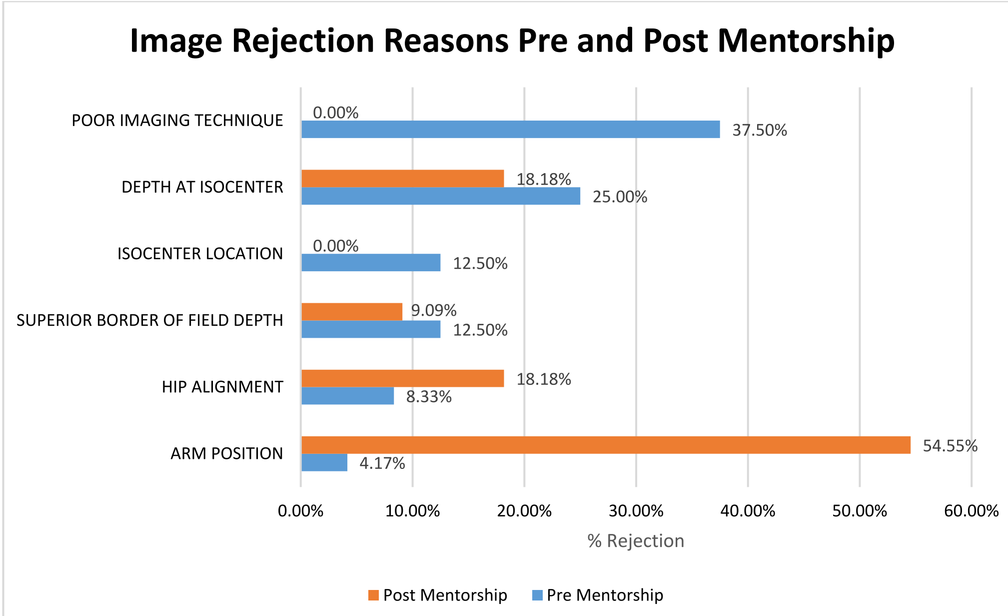

Fig. 1. A Comparison of Image rejection Reasoning Pre and Post mentorship

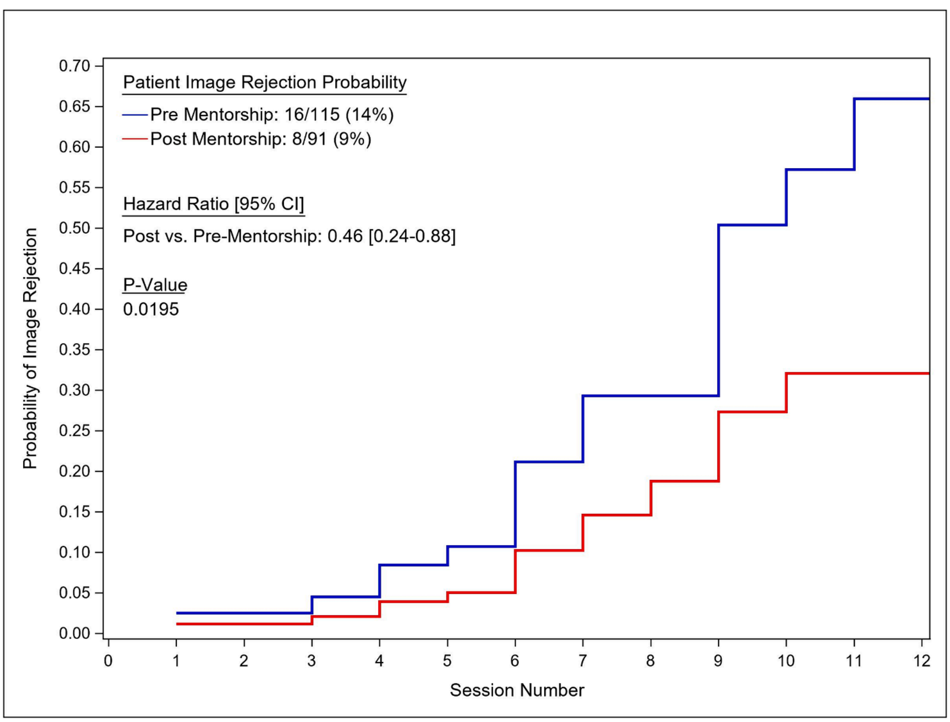

Fig. 2. Intensity model comparing pre and postmentorship Breast Image rejection probability

beam manipulation during treatment planning, fewer shifts at simulation setup, and more efficient and reproducible setup on verification day. Since radiotherapy errors often progress to geometric misses as a result of incorrect patient setup, enhancing workflows to improve patient simulation could significantly reduce error, thereby decreasing the time required for verification, the likelihood of reproducibility errors, and the patient distress created by delays and repeat procedures [20,21]. This update to workflows was implemented post-mentorship for the Department's breast imaging procedure.

In-depth consideration by the RTT, RO, and medical physicists of the benefits of minimizing beam manipulation during treatment planning led to a critical improvement in planning documentation: development of a new visual aid depicting beam edge variance from the original beam arrangement at simulation. Updated documentation helped reduce queries during patients' table time, leading to more efficient and accurate verification setup and, importantly, less patient discomfort.

The second phase of the mentorship centered on the mechanics of image retrieval and review using the Review Tool in the MOSAIQ EMR. The RO described in detail, case-by-case, how her perspective and decision making are informed by patients' distinct clinical needs. Based on new understanding of the nuances and complexity of review, the RTT suggested an enhancement to the therapy team review process. Prior to the mentorship, the treating therapy team reviewed images in the on-board imaging system (OBI) at the machine in real time. Therapy teams now save images in MOSAIQ using the tools provided by the software, allowing for a more thorough review.

The RO and RTT also considered common causes of breast image rejection, specifically incorrect positioning of the shoulder and supraclavicular region in 3-field breast treatment plans [21,22,23]. To address this challenge, our therapists were asked to readjust their setup, placing greater attention on reducing inaccuracies. The RO and RTT conducted an informal retrospective review of image rejection rates at our institution, which revealed challenges related to arm position and hip alignment. The RTT suggested adding an anteroposterior view (AP KV) into the initial workflow verification of 3-field breast setup, which provides a higher contrasting image and allows the therapist to correct for whole body positioning errors before proceeding to higher dose megavoltage (MV) imaging. The addition of AP KV could reduce the number of poor exposures and technologist operational errors often seen with the use of multiple MV ports. The addition of the AP KV falls within the RTT's ALARA (as low as reasonably attainable) principles. Post-mentorship, AP KV during the initial workflow was adopted as the Standard Practice for breast imaging in our Department.

During the first two phases of the mentorship, the RTT shared the knowledge acquired related to patients' often complex clinical histories prior to treatment and the nuances of setup and beam arrangements in therapy team meetings and through informal conversations with therapists in the Department. These conversations encouraged deeper empathy with the breast patient population and greater engagement with treatment teams.

During the third phase of the mentorship, the RTT studied first day verification images of five new patients prior to the RO's review, applying the clinical perspective gained during the prior phases of mentoring. The RO and RTT attained 100 % concordance (approval/rejection). During this phase of the mentorship, the mentee observed several challenges that led to updating breast imaging best practices in the Department. Positional shifts occurring on Day 1 of treatment were often removed on repeated imaging on Day 6. While shifts were typically minimal with no overall effect on outcomes, the RTT understood that the initial treatment is often physically stressful for patients resulting in inaccuracies in positional setup. As the patient relaxes, however, these shifts may not be consistent and become redundant. Recognizing and accounting for patients' stress on Day 1 may help ensure the capture of an accurate image during the initial session.

To address this shift, the RTT proposed new departmental workflows that would be responsive both to American College of Radiology (ACR) and American Society for Radiation Oncology (ASTRO) guidelines regarding an RO's decision making around acceptable or unacceptable day-to-day variations in the treatment setup while also better meeting the specific needs of the breast population [24]. If there are no shifts from planned isocenter on Image Day 1, re-film occurs after 5 days; if there are shifts from planned isocenter on Day 1, re-film occurs on Day 2; and then, if consistent, on Days 2 and 3, re-film proceeds to weekly. Shifts needed on Day 1 were often unnecessary on subsequent days. As patients relaxed into position following their initial treatment, fewer shifts were required. These imaging best practices and workflow updates have now been formally implemented for the breast imaging service. The RTT discussed the reasoning behind and purpose of updating workflow best practices with the therapy team, which has inspired deeper understanding of the ways in which stress at the time of initial verification could affect setup (i.e., nervousness resulting in agitated movement, anxiety about pain or side effects). Post-mentorship, the APRT developed a process for all 3D treatment plans (for all populations) to include initial setup of KV images before imaging treatment portals to improve workflows, accuracy, and, consequently, patients' experience, which has been implemented as a best practice.

While patient setup is essential to ensure accurate delivery of radiotherapy, many radiation oncology residency programs offer little, if any, training in image review [21]. Recognizing this gap, the RTT developed an image review educational module which was approved by the Department, and which is now required of all incoming Radiation Oncology residents and rotating therapists. Going forward, the APRT will continue to teach this newly implemented educational session, well as a new course on image review for all medical and therapy students. She plans to pursue similar mentorships to attain competency for other high-volume populations, specifically prostate and head/neck cancer patients. The APRT can engage in image verification approval for the breast population, performing the same role as a resident. The department policy will be updated when other competencies are completed for other patient populations. The RO, APRT, and departmental colleagues and leaders have established a national working group with the goal of building a network of individuals across the U.S. focused on demonstrating the promise and potential of the APRT model. Finally, the mentorship will serve as the basis for mentorship and proficiency in image review for other clinical treatment sites at our institution, and for other appropriate task shifting between the RO and the APRT in the radiotherapy clinic.

Our study has several limitations. The RTT had been working as a clinic supervisor in the breast imaging service at the time of the mentorship and may reflect bias given her high engagement with this patient population. The effects of specific mentoring activities on image rejection rates were not analyzed. The mentoring period overlapped in part with the review of images post-mentorship and rejection rates were not tracked by month. However, image rejection rates declined at later time points during/post-intervention suggesting that mentoring may have influenced the RTT's performance while it was underway. The broader impacts (i.e., improvements to breast imaging best practices, etc.) were not anticipated and were therefore not evaluated.

Conclusion

This study investigated image rejection rates for a breast population before and after a RO-RTT mentorship intervention. Analysis of image rejection is an essential Quality Assurance tool within Radiation Oncology departments, helping to tailor Quality Improvement (QI) initiatives to address the causes for rejection and identify gaps in workflow, and improve best practices. Clear understanding of the causes of, and reasons for, image rejection requires multidisciplinary collaboration, which can foster greater engagement of treatment teams overall, help identify areas where additional education and training may be needed and improve care delivery. The APRT role can have significant impact on enhancing service capacity, improving resource utilization, increasing knowledge dissemination, and most importantly on transforming patient experience as therapy practices respond to increasing demand and increasingly complex care delivery challenges.

Data Sharing Statement: The authors confirm that the data supporting the findings of this study are available within the articles (and/or) its supplementary materials.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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