原 著

Proposal for training that does not use radiotherapy equipment and verification of training effects

放射線治療装置を使用しない実習の立案と実習効果の検証

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Key words: Undergraduate education, practical training, radiotherapy, dosimetry, particle beam therapy

【Abstract】
Purpose: The purpose of this study was to design effective radiotherapy training that can be used even in facilities without radiotherapy equipment and to verify its educational effects.
Methods: Practical training was planned and implemented for five themes: medical safety, brachytherapy, dosimetry, external irradiation, and proton therapy. After the practical training, a questionnaire survey was conducted to verify the educational effects.
Results: The Students scored 4 or higher out of 5 for all of the questionnaire items of each training theme. Interest in radiotherapy increased significantly after receiving the practical training.
Discussion: Many students evaluated the practical training highly, and it seemingly increased their interest in radiotherapy. In the future, it will be necessary to further examine the contents of hands-on training and aim to improve the training.

【要 旨】
目的：本研究は，放射線治療装置を有しない施設における，効果的な放射線治療実習の立案とその教育効果の検証を目的とした．
方法：医療安全，密封小線源治療，線量測定，外照射，陽子線治療の５テーマについて，実習を立案・実施した．実習後，アンケート調査により教育効果の検証を行った．
結果：実習テーマ全てのアンケート項目で，５段階評価で４以上であった．実習後，放射線治療への興味は有意に増大した．
考察：多くの学生が実習を高く評価し，放射線治療への興味を増したことから，本実習が臨床実習への橋渡しの役割を果たすことができたと考える．今後，体験型の実習内容をさらに検討し，実習改善を目指すことが必要と言える．

Introduction

In Japan, the regulations for the designation of radiological technologist schools and training institutes were modified in 2015 in response to business expansions due to the revision of the Radiological Technologists Act in 2014. Along with the modification, a review committee for improving the curriculum and other aspects of the training school for radiological technologists was established under the Ministry of Health, Labor and Welfare, and in March 2021, new guidelines for the training school were established. The purpose of the guidelines were to “improve the quality of clinical training for advanced medical personnel via by learning basic radiological techniques through practice in clinical settings in order for them to appropriately respond to patients with diverse needs.” The current 10 units of clinical training will be expanded to 12 units. In addition, it has been proposed that “mandatory

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Received July 10, 2023; accepted December 5, 2023

preclinical evaluations should be conducted in order to confirm in advance if applicants have the appropriate knowledge, skills, and attitudes desired for clinical training."

Clinical training in radiological technologist education is a valuable opportunity to convert the knowledge and skills learned thus far into practical ones. Basic knowledge is acquired via pre-practice education so that students can experience things that cannot be learned in classroom lectures in clinical practice. This is so they can find and organize the issues they need on their own. In addition, it is desirable for students to learn the atmosphere of an actual hospital. If an educational institution is equipped with sufficient medical equipment, it is possible to have students experience and learn in a way that is close to that of the real world. But many facilities do not have radiotherapy equipment because it is expensive. Radiotherapy is a minimally invasive and low-impact cancer treatment, and its use is on the rise as the number of cancer patients increases. There are 6.2 million radiation treatments performed annually worldwide[1]. In recent years, there has been an increase in medical accidents due to over- or under-irradiation in radiotherapy, not only in Japan but also in many hospitals around the world. These have made people aware of the potential dangers of radiotherapy, which is in increasing demand, and called into question the need for awareness of medical safety[2]. The work of radiological technologists continues to increase and is becoming more complex, and the technology is expected to grow as medical care advances[3]. It is believed that the knowledge and abilities necessary for the implementation of accurate and safe treatment will change, and it has been reported that the education and training of radiological technologists need to be improved[4]. In the Japanese curriculum, the number of credits for radiotherapy technology was revised from six credits to seven credits. Specifically, students will be required to study the principles of radiotherapy and of particle beam therapy and the measurement and evaluation of absorbed doses. In this way, the importance of education of radiotherapy is being recognized again. Radiotherapy differs in the diagnostic field in many respects, such as the appearance of the device, handling of the brachytherapy source, quality control, and medical safety. Therefore, if clinical training starts without sufficient pre-training education, sufficient educational effects will not be obtained. In this study, we proposed an effective practical training protocol for radiological technologists before clinical training, even at educational facilities that do not have radiotherapy equipment. Moreover, the educational effect of the practical training was examined via a questionnaire survey.

Methods

1. Training content

In the FY 2021 Medical Radiological Technology Practicum I course at a four-year university with a clinical radiology department, an on-campus practical training titled "The Basics of Radiotherapy" was carried out. The targets were 89 students, and the practical training was divided into groups of about 10 people, with practical training sessions of 90 minutes × three sessions. The themes were (1) medical safety, (2) brachytherapy, (3)dosimetry (QA, QC), (4) external irradiation, and (5) proton

Table 1 Practice schedule
The practical training study was conducted in three periods of 90 minutes each. The themes of medical safety, brachytherapy, dosimetry (QA, QC), external irradiation, and proton therapy were dealt with according to the schedule shown in the table.

Time	Learning items
13:00–13:45	① Medical safety
13:45–14:30	② Brachytherapy
14:30–14:40	rest
14:40–16:10	③ Dosimetry (QA, QC)
16:10–16:20	rest
16:20–17:05	④ External irradiation
17:05–17:50	⑤ Proton therapy

therapy. These were implemented according to the schedule shown in Table 1.

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The contents of each theme are detailed below.

① Medical safety

After lectures on medical safety, medical adverse events, and incident reports, the students were asked to write incident reports using examples.

② Brachytherapy

We outlined the flow of brachytherapy and gave a lecture on how to plan treatment. After that, for practical training, students were shown points A and B, which were important dose evaluation points in the Remote After Loading System, on an illustration of the uterus.

③ Dosimetry (QA, QC)

Lectures on dose measurement and standard dosimetry of the absorbed dose to water in external beam radiotherapy 12 were given with calculation problems. After that, we let the students experience the flow from dose measurement using Excel to monitor unit calibration.

④ External irradiation

Two videos (deep inspiration breath hold for left breast cancer and Intensity-Modulated Radiation Therapy for the head and neck) were shown to demonstrate actual radiotherapy. After watching the video, the students summarized the flow of radiotherapy.

⑤ Proton therapy

After explaining the characteristics of proton beam therapy, representative cases, and an overview of the treatment equipment, we practiced using Excel to create a spread-out Bragg peak from a monopeak.

1) Impressions of each training theme
  [1] Explanation was sufficient and easy to understand
  [2] Handouts were thorough
  [3] The time given for the training content was appropriate
  [4] I understood the content
  [5] I am satisfied with the content
2) Are you glad to have received this training in preparation for your clinical training?
3) Interest in radiotherapy
  [1] Were you interested in radiotherapy before taking this practice?
  [2] Are you interested in radiotherapy after taking this practice?
4) Other, free comments

Fig.1 Training questionnaire contents

Except for free comments, responses were evaluated on a 5-point scale, wherein 5: Strongly agree, 4: Agree, 3: Neither agree nor disagree, 2: Disagree, and 1: Strongly disagree.

2. Conducting the questionnaire survey

An anonymous questionnaire was conducted after the end of the on-campus clinical training. At the time of conducting the questionnaire, we informed students that the content of the answers had no effect on their grades. As shown in Fig.1, the contents of the questionnaire were roughly divided into four parts: 1) Impressions of each training theme, 2) Whether or not the training was good for clinical training, 3) Interest in radiotherapy, and 4) Free comments. Responses were evaluated on a 5-point scale, wherein 5: strongly agree, 4: agree, 3: neither agree nor disagree, 2: disagree, and 1: strongly disagree. The reason for using the five-case method, which includes intermediate values, is because we thought that (1) we would obtain data from an intermediate group that could not be judged either way, and (2) a certain number of students would find it difficult to give a negative answer due to their position as students.

3. Changes in grades before and after practical training

In parallel with this practical training, a lecture on radiotherapy technology II was being held as a subject for the first semester of the

third year. In order to evaluate the learning effect of the practical training, we compared the final examination results of 2020, before this practical training was conducted, and the results of 2021, when the practical training was conducted.

4. Data analysis/statistics

In the content 2(Conducting the questionnaire survey), in order to verify the content of Question 3) Interest in radiotherapy, we examined the significance of the planned practice via Wilcoxon's signed-rank test with matched samples. In the content 3(Changes in grades before and after practical training), Welch's t-test with independent samples was used to examine the significance of the change in performance before and after the practical training. SPSS ver.28.0.0.0 (IBM) was used for all of the statistical processing, and the statistical significance level was set at 5%.

5. Research ethics

This research was conducted with the approval of the president after review by the ethics committee of the research institution (approval number R04-8). The author and all co-authors have no conflicts of interest directly relevant to the content of this article. The research was explained to the target students during the guidance time. At that time, we informed them that the survey would be anonymous and that the results of their responses would have no bearing on their grades, and obtained their written consent. An outline of the study was also posted on a bulletin board, and sufficient time was allowed for withdrawal of consent.

Results

Fig.2 shows the questionnaire results for each training theme. Across all of the question items, the total number of students that strongly agreed or agreed fell no lower than 73 (82.0%). In other words, more than 80% of the students gave a high evaluation of the course content overall. More than 90% of the students answered that they were "satisfied" with the theme other than external irradiation (79 students [88.8%] for external irradiation). There was no significant difference in the number of respondents who answered "strongly agreed" or "agreed" for each theme. The least number of respondents answered "strongly agreed" or "agreed" for the question "I understood the content" among all themes.

There was no negative answer to the question "Are you glad to have received this training in preparation for your clinical training?", and more than 80% of the students answered that they strongly thought so (Fig.3).

Fig.4 shows the interest in radiotherapy before and after the practical training. The number of respondents who answered "strongly agree" and "agree" increased significantly, which indicates that the interest in radiotherapy significantly improved after the training (before training: 3.5, after training: 4.2; $p < 0.001$).

In terms of free comments, we received the following: "I felt that the appearance of the engineer in the video was very cool. Through this practical training, my awareness of hospital training increased, and I felt that I would like to make use of it in the actual workplace." In addition to such positive opinions, we also received other opinions, including the following: "I wanted to be more active than as a participants in classroom lectures. I wish there were more discussions with teachers and between students." Other opinions were also received.

Fig.5 shows a comparison of the results of the final examination of radiotherapy technology II between the 2020 third-year students, who did not have practical training, and the 2021 third-year students, who had this practical training. Compared to the previous year, the results significantly improved, and the median score increased by 26.9 points.

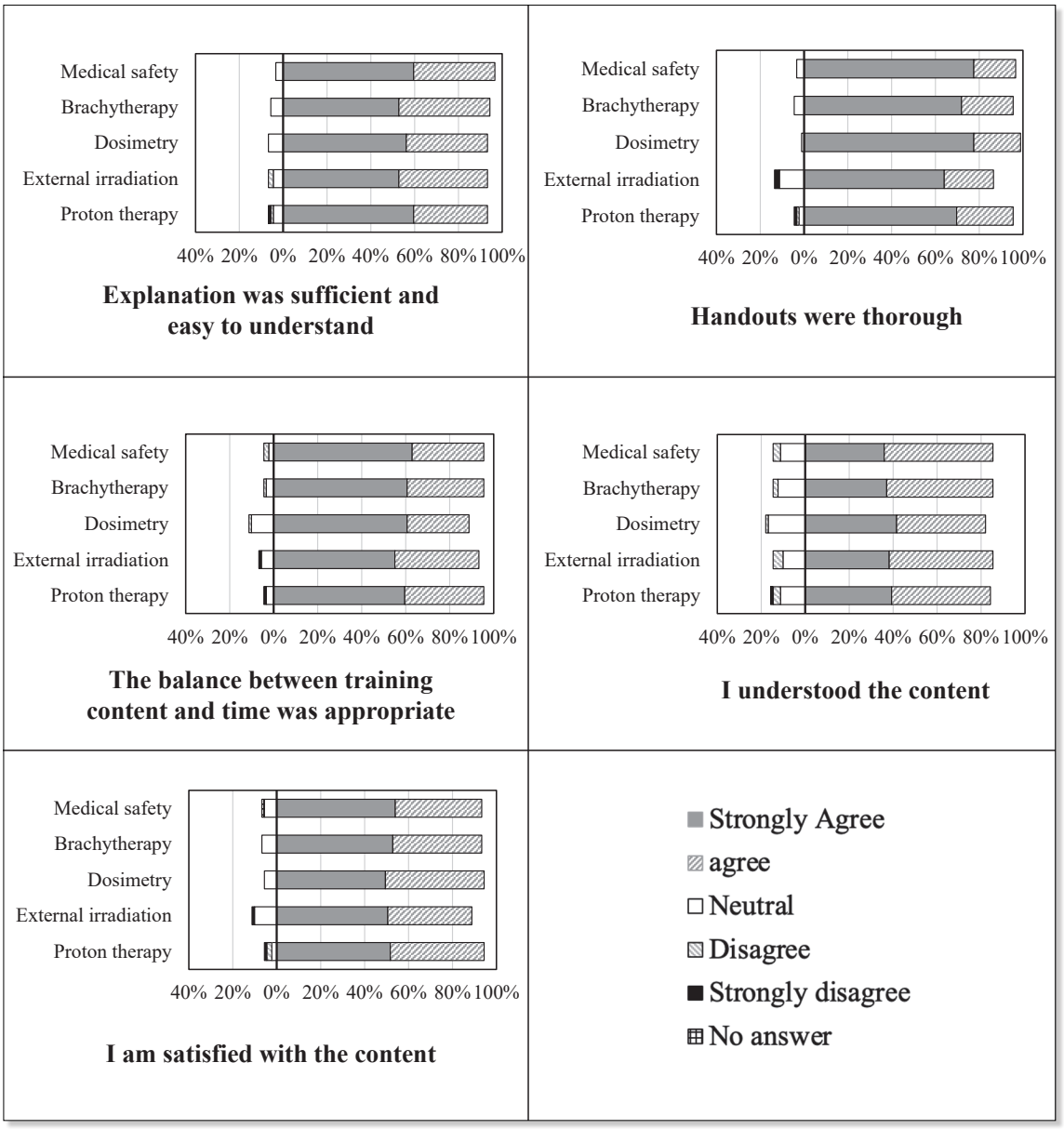

Fig.2 Practical questionnaire results

The results of the "impressions of each training" theme in the training questionnaire are shown. More than 80% of the students answered "strongly agree" or "agree" to all of the question items.

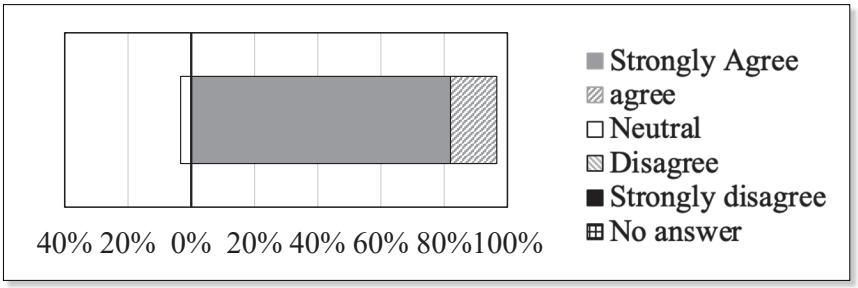

Fig.3 Practical questionnaire results

—Are you glad to have received this training?—

This figure shows the results of the practical training questionnaire, "Was it good to receive this training for clinical training?" More than 80% of the students answered "strongly agree."

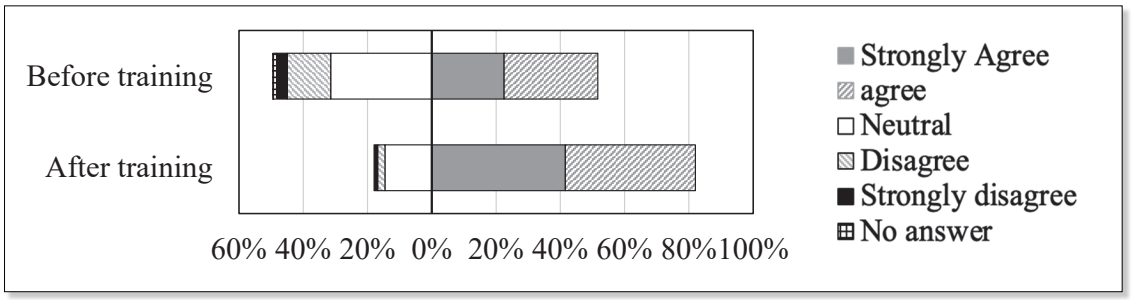

Fig.4 Practical questionnaire results

—Are you interested in radiotherapy?—
The results of "interest in radiotherapy" in the practice questionnaire are shown. The interest in radiotherapy increased significantly after the practical training.

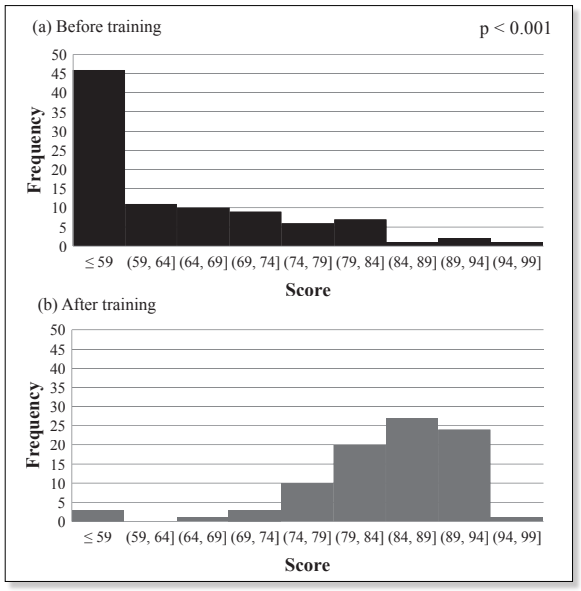

Fig.5 Comparison of radiotherapy technology II test results

A comparison of the final examination results of radiotherapy technology II (third-year students) in 2020, before practical training was not conducted, and in 2021, when this practical training was conducted, is shown.

Discussion

Many students gave the practical training a high evaluation, and their interest in radiotherapy increased. It is thought that this training could serve as a bridge to clinical training. With regard to the method of clinical training, it is said that a format in which clinical trainees participate as members of the medical care team is desirable[5]. It is thought that this practical training was also highly evaluated because it was possible to get a real feeling of practical training by incorporating a lot of time to actually move hands on multiple themes.

One of the reasons for the improvement in the results of the radiotherapy technology II examination was that the students' understanding of the lectures was further deepened by the lectures being held at the same time as the practical training. Lecture-style guidance can convey a lot of information in a limited amount of time, but it tends to be a one-way communication of information, and students are likely to be passive and less motivated[6-8]. The themes dealt with in this practical training, such as dose calculation and irradiation methods, are difficult to convey in classroom lectures, so it is effective to have students learn by actually using their own hands. The synergistic effect of classroom lectures and practical training can be applied to other fields, suggesting the possibility of greatly contributing to the improvement of educational effects. In order to further enhance the effectiveness of learning and training, it is important not only to improve quality independently, but also to deepen the relationship by being aware of both sides of the issue and complementing each other. However, the improvement in scores in this study was a comparison of different grades, and it is possible that differences in backgrounds such as the level of the students and their interest in radiotherapy may have contributed to the improvement in scores. Although a comparison between the groups that received the practical

training and those who did not is effective in evaluating the improvement in performance, the practical training is a required course to all students, and it is difficult to obtain data on groups that do not experience practical training.

Regarding the reason why the theme of external irradiation was rated lower than the others, the content was mainly video, and there were few handouts compared to other themes. In addition, the teacher stopped the videos one by one and added explanations. These were considered to be the factors that lowered the level of satisfaction. In order to raise the level of "understandability" to that of the other practical training themes, the contents of the videos need to be further improved.

One of the other points to be improved in this training was that as a result of pursuing things that can be easily done without a linear accelerator, desk work has become the main focus. In the questionnaire results, the number of respondents who strongly agreed or agreed with "I understood the content" was smaller than the others. This was thought to be because although teachers provided sufficient explanations and materials to the students, the students lacked the motivation to actively deepen their understanding due to the decrease in opportunities for students to think and speak for themselves. In the educational evaluation of clinical training, it is desirable to use an evaluation method that enables close communication between clinical training instructors and trainees, indicates specific goals, and confirms the process of self-development[9,10]. To incorporate the opinions of students who wanted to be more active and engaged in discussions, we recommend introducing Objective Structured Clinical Examination (OSCE)[11] and conducting group discussions on incidents and videos viewed. This time, five themes were implemented in 90 minutes × three sessions, so it was difficult to prepare enough time for a discussion. We believe it is necessary to increase the training time and to devise better methods for pruning and selecting training content.

Conclusion

We planned effective training even at treatment facilities that did not have radiotherapy equipment and examined the educational effects through a questionnaire survey.

Based on the educational curriculum for radiological technologists, we were able to build practical training with a high degree of student satisfaction by incorporating the principles of particle beam therapy and the measurement and evaluation of the absorbed dose.

In an effort to achieve more participatory training, it is necessary to aim for further training improvement centered around the keystones of "active participation" and "discussion."

Acknowledgments

I would like to express my deep gratitude to all of the students who cooperated with the questionnaire survey in advancing this research.

表の説明

Table 1　実習スケジュール
説明文：実習は90分3コマで行われた．Tableに示したスケジュールで医療安全，密封小線源治療，線量測定（QA，QC），外照射，陽子線治療の5テーマを取り扱った．

図の説明

Fig.1　実習アンケート内容
説明文：フリーコメントを除き，回答は5：強くそう思う，4：そう思う，3：どちらともいえない，2：そう思わない，1：全くそう思わない，の5段階で評価した．

Fig.2　実習アンケート結果
説明文：実習アンケートにおける「実習テーマごとの感想」の結果を示す．全ての質問項目において，8割以上の学生が「強くそう思う」，もしくは「そう思う」と回答した．

Fig.3　実習アンケート結果
—実習を受けて良かったか—
説明文：実習アンケートにおける「臨床実習へ向けて本実習を受けて良かったか」の結果を示す．8割以上の学生が「強くそう思う」と回答した．

Fig.4　実習アンケート結果
—放射線治療に興味はあるか—
説明文：実習アンケートにおける「放射線治療への興味」の結果を示す．実習を行ったことで放射線治療への興味は有意に増大した．

Fig.5　放射線治療技術学Ⅱ試験結果の比較
説明文：実習が行われていなかった2020年度と，本実習が行われた2021年度の，放射線治療技術学Ⅱ（3年生科目）の期末試験結果の比較を示す．

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