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Original Article

A survey of the participants' learning outcomes after finishing the dental radiology course for the continuing education of medical radiation technologists in Taiwan

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KEYWORDS
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Abstract *Background/purpose:* In Taiwan, there are very few dental radiology curricula in medical radiation education system. This study assessed the participants' learning outcomes after finishing the dental radiology course for the continuing education of medical radiation technologists in Taiwan.

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Medical radiation technologist continuing education;
Medical radiation technologist

Materials and methods: This study used the questionnaire survey to evaluate the participants' learning outcomes after finishing the dental radiology course for the continuing education of medical radiation technologists in Taiwan.
Results: In this study, 85 participants filled out the questionnaires completely after finishing the dental radiology course. The majority of participants agreed that dental radiology courses were rare in the medical radiation school curricula and the continuing education courses of medical radiation technologists. Moreover, most of participants found this course to be helpful in raising their basic knowledge about the dental radiology, their attitude towards the dental radiology, and their interest in further learning of the dental radiology. They were satisfied with the courses. The degree of agreement for each question was high with all the mean scores for each question being between 3.87 and 4.61. The numbers (rates) of respondents who answered as agree were between 58 (68.24%) and 84 (98.82%).
Conclusion: The dental radiology course for the continuing education of medical radiation technologists is found to increase the participants' basic knowledge about the dental radiology, and their awareness and understanding of the radiation protection in dental radiography. Thus, this model can be further used for the dental radiology course for the continuing education of medical radiation technologists in Taiwan.

Introduction

In the late 1895, Wilhelm Conrad Roentgen discovered X-rays, while in the early 1896, two weeks after Roentgen's discovery published, the German dentist Otto Walkhoff obtained an X-ray radiograph of his own teeth with the help of Fritz Giesel. This story presents the fact of the birth of the world's first X-ray radiograph of human teeth, and the appearance of the world's first character whose role was to assist a dentist in the dental radiation work. Since then, the use of X-ray in medical and dental radiography has spread throughout the world. Additionally, the first X-ray machine for the diagnosis of dental and jawbone diseases was manufactured by the current German company Siemens in 1905.[1–3] Thus, the field of dental radiology has existed for more than 120 years, while the professionalism of technicians engaged in the dental radiation work has also developed simultaneously.

There was an article that introduced the value of X-ray for the diagnosis of dental diseases with photobook published in the Journal of the Formosan Medical Association by the Taiwan Government Taipei Hospital in 1913. This might prove that Taiwan already had the dental X-ray machines before the early 1910s. In addition, there was another article that introduced the dental X-ray radiography technology published in the Journal of the Taiwan Radiology Association by the Radiology Department of Taiwan Government Tainan Hospital in 1932. This might further prove that the dental X-ray machines had been commonly used by the dentists for their dental practice in Taiwan by the 1930s.[4,5] Therefore, the usage of the dental X-ray machines has a history of more than 100 years in Taiwan.

In Taiwan, in terms of education system, the formal education for cultivating medical radiation technologists began in 1965 at Yuanpei Junior College (restructured into a university in 2005), while in terms of the licensing system, the formal national examination for licensing medical radiation technologists began in 1978. In addition, the legal system of Medical Radiation Technologists Act (MRTA) was established in 2000. At present, there are 10 medical radiation schools in Taiwan that cultivate medical radiation technologists. However, even though the dental radiology has a long history in Taiwan, it has not yet developed a standardized dental radiology education system. For undergraduate medical radiation students, some medical radiation schools do not provide independent dental radiology course, resulting in many medical radiation students almost completely lacking the concept and knowledge of dental radiology.[5–7] The dental radiology is a common field of dentistry and medical radiology. Therefore, it is worthwhile for the medical radiation technologists to enrich their knowledge and skill related to the dental radiology in their professional career.

According to Taiwan's Ionizing Radiation Protection Act (IRPA), the education and training of ionizing radiation protection is obligatory for the medical radiation workers. In addition to the dentists, the medical radiation technologists are the only personnel who can legally operate the dental X-ray machines. Moreover, the medical radiation technologists are so-called radiation workers in the IRPA. The Taichung City Association of Radiological Technologists (TCART) designed a 3-h dental radiology course for the continuing education of medical radiation technologists in 2023. In addition to the medical radiation technologists, the relevant practitioners were also welcome to participate in this continuing education course.

This 3 h dental radiology course was an introduction to the concept of dental radiology, and aimed to enhance the participants' understanding of the growing relationship between dental procedures and dental radiography through an introduction to the dental radiography techniques. The purpose of this study was to assess participants' learning outcomes after finishing the dental radiology course for the

continuing education of medical radiation technologists in Taiwan. Thus, a questionnaire survey was conducted to understand whether the dental radiology course for the continuing education of medical radiation technologists could increase the participants' basic knowledge about the dental radiology and their awareness and understanding of the radiation protection in dental radiography. The results of this study could be further used as a reference for the establishment of the dental radiology course for the continuing education of medical radiation technologists in Taiwan.

Materials and methods

Participants

All subjects participating in the dental radiology course entitled "Dental Radiography and Radiation Protection" for the continuing education of medical radiation technologists offered by the TCART in July 2023 were included in this study. Their gender, practice experience, main working field, and professional occupation were confirmed by the questionnaire survey and were used as the basis for grouping the participants.

Teaching process

This continuing education course was a specific 3-h dental radiology course for the in-service medical radiation technologists and the relevant practitioners. It was performed in the form of lectures and was offered to the TCART members who were mainly the medical radiation technologists. The course content included the principles and techniques of dental radiography, and the radiation protection in dental radiography. It was taught by a senior medical radiation technologist working in the Department of Dentistry of National Taiwan University Hospital (NTUH). An online questionnaire link was given to the participants who completed this dental radiology course after the class.

Survey tool

This study used the method of dental radiology education survey by questionnaire to evaluate participants' learning outcomes by assessing their perceptions of the dental radiology course. All participants who completed this dental radiology course were invited to fill out the questionnaires for the dental radiology education survey after the class. The purpose of this survey was to analyze the participants' cognition for the concepts of dental radiology after the course. All participants were invited to join in this survey at their free will to fill out the questionnaires without the pressure from the investigators.

A structured questionnaire-based online survey was used as the survey tool to understand participants' cognition and attitude for the dental radiology. The questions about the participants' basic information included their gender, practice experience, main working field, and professional occupation, as well as the main reasons for participating in this course and their learning experience about the dental radiology before this course. The questionnaire was designed for obligating the participants to answer all the questions and to make sure that the returned electronic survey forms were all complete. The investigated questions included (1) the experience about the dental radiology courses in the medical radiation school curricula and in the continuing education courses (questions 1 and 2), (2) the self-assessment of participants' cognition for knowledge about the dental radiology (questions 3 and 4), (3) the attitude towards the dental radiation protection and interest in further learning of the dental radiology (questions 5, 6 and 7), and (4) the personal viewpoint for this dental radiology course (questions 8 and 9).

In the investigated questions, the answer was designed to let the participant to raise a score ranging from 1 to 5. If the intensity or response for each question was extremely agreed, the score was 5. If the intensity or response for each question was neutral, the score was 3. In contrast, if the intensity or response for each question was extremely disagreed, the score was 1. The mean score of 3 or more meant that on average answerers agreed the investigated questions, and the higher the score, the higher the degree of their agreement. The participants were suggested to fill the score or answer in fresh memory.

Statistical analysis

All data obtained from the participants were stored in excel files and used for statistical analysis. The differences in the mean scores (the degree of agreement) of various investigated items were compared between two different groups of the participants by independent sample *t-test*. The result was considered to be significant if the *P*-value was less than 0.05.

Results

Demographic data

A total of 88 participants who completed the dental radiology course for the continuing education of medical radiation technologists offered by the TCART in July 2023 were included in this study. Among them, 85 participants filled out the questionnaires completely after the class. The valid response rate was 96.59%. Of these 85 respondents, there were 30 (35.29%) males and 55 (64.71%) females. For the practice experience, most of them had the working experience of less than 10 years (30, 35.29%), followed by between 11 and 20 years (29, 34.12%), between 21 and 30 years (22, 25.88%), and between 31 and 40 years (4, 4.71%). For the main working field, most of them were engaged in the diagnostic radiology (48, 56.47%), followed by the radiation therapy (13, 15.29%), the nuclear medicine (12, 14.12%), and others (12, 14.12%). In addition, for the professional occupation, most of them were the medical radiation technologists (58, 68.24%), followed by the medical radiation technologists with the radiation protection personnel certificates (16, 18.82%), the medical staff (8, 9.41%), and others (3, 3.53%) (Table 1).

Table 1 Distribution of respondents (n = 85) who filled out the questionnaires after finishing the continuing education course entitled "Dental Radiography and Radiation Protection" for the continuing education of medical radiation technologists offered by the Taichung City Association of Radiological Technologists (TCART) in July 2023.

Category	Number (proportion) of respondents (n = 85)			
Gender	Male	Female		
	30 (35.29%)	55 (64.71%)		
Practice experience	0—10 years	11—20 years	21—30 years	31—40 years
	30 (35.29%)	29 (34.12%)	22 (25.88%)	4 (4.71%)
Main working field[a]	Diagnostic radiology	Radiation therapy	Nuclear medicine	Others
	48 (56.47%)	13 (15.29%)	12 (14.12%)	12 (14.12%)
Professional occupation[b]	Medical radiation technologist	Medical radiation technologist with radiation protection personnel certificate	Medical staff	Others
	58 (68.24%)	16 (18.82%)	8 (9.41%)	3 (3.53%)

[a] Others in the main working field included surgery, cardiac catheterization, ultrasound, mammography, dental photography, and medical engineering.
[b] Medical staff in the professional occupation included physicians and nurses, while others in the professional occupation included electrical maintenance personnel, radiation protection personnel, and medical physicists.

Main reasons for participating in this dental radiology course for the continuing education of medical radiation technologists

As for the main reasons for participants to choose this dental radiology course, the questionnaire offered three reasons for selection and these included (1) interesting course topics, (2) convenient location for the classes, and (3) accumulating the continuing education points. Multiple selections are allowed. The sum of the frequencies of various reasons being chosen was 149 in total. Overall, among the three reasons, the highest frequency (proportion) was to accumulate the continuing education points (70, 46.98%), followed by the convenient location for the classes (44, 29.53%) and the interesting course topics (35, 23.49%). Only among the participants whose professional occupation were others, the highest frequency (proportion) was the interesting course topics (3, 50%). Among the participants based on various other groupings, the highest frequency (proportion) was always to accumulate the continuing education points. Especially among the medical radiation technologists, the frequency (proportion) of accumulating the continuing education points was as high as 50 (50.51%) (Table 2).

Table 2 Main reasons of respondents for participating in the dental radiology course for the continuing education of medical radiation technologists.

Category	Frequency (proportion) of reasons (n = 149)		
	Interesting course topics	Convenient location for the classes	Accumulating continuing education points
Gender			
Male	17 (30.36%)	15 (26.79%)	24 (42.86%)
Female	18 (18.75%)	29 (30.21%)	46 (47.92%)
Practice experience			
0—10 years	10 (20.41%)	16 (32.65%)	23 (46.94%)
11—20 years	12 (23.53%)	15 (29.41%)	24 (47.06%)
21—30 years	10 (25%)	10 (25%)	20 (50%)
31—40 years	3 (33.33%)	3 (33.33%)	3 (33.33%)
Main working field			
Diagnostic radiology	24 (27.91%)	21 (24.42%)	41 (47.67%)
Radiation therapy	6 (24%)	8 (32%)	11 (44%)
Nuclear medicine	3 (15.79%)	7 (36.84%)	9 (47.37%)
Others	2 (10.53%)	8 (42.11%)	9 (47.37%)
Professional occupation			
Medical radiation technologist	21 (21.21%)	28 (28.28%)	50 (50.51%)
Medical radiation technologist with radiation protection personnel certificate	9 (29.03%)	9 (29.03%)	13 (41.94%)
Medical staff	2 (15.38%)	5 (38.46%)	6 (46.15%)
Others	3 (50%)	2 (33.33%)	1 (16.67%)
Overall	35 (23.49%)	44 (29.53%)	70 (46.98%)

Table 3 Respondents' learning experience about the dental radiology before the dental radiology course for the continuing education of medical radiation technologists.

Learning experience	Number (proportion) of respondents (n = 85)	
	Yes	No
A. I had the learning experience about the dental radiology in my school curricula.		
Medical radiation technologist (n = 58)	13 (22.41%)	45 (77.59%)
Medical radiation technologist with radiation protection personnel certificate (n = 16)	3 (18.75%)	13 (81.25%)
Others (n = 11)	0 (0%)	11 (100%)
Overall	16 (18.82%)	69 (81.18%)
B. I had the learning experience about the dental radiology in my continuing education courses.		
Medical radiation technologist (n = 58)	10 (17.24%)	48 (82.76%)
Medical radiation technologist with radiation protection personnel certificate (n = 16)	2 (12.5%)	14 (87.5%)
Others (n = 11)	0 (0%)	11 (100%)
Overall	12 (14.12%)	73 (85.88%)

Learning experience about the dental radiology before this dental radiology course for the continuing education of medical radiation technologists

As for the learning experience for participants about the dental radiology, this questionnaire offered two questions for selection and these included (1) I had the learning experience about the dental radiology in my school curricula and (2) I had the learning experience about the dental radiology in my continuing education courses. Based on the participant responses, only 16 (18.82%) of the 85 participants had the learning experience about the dental radiology in the school curricula, and only 12 (14.12%) of the 85 participants had the learning experience about the dental radiology in the continuing education courses. Among the medical radiation technologists, only 22.41% (13/58) and 17.24% (10/58) had the learning experience about the dental radiology in their school curricula and in their continuing education courses, respectively. Moreover, among the medical radiation technologists with the radiation protection personnel certificates, only 18.75% (3/16) and 12.5% (2/16) had the learning experience about the dental radiology in their school curricula and in their continuing education courses, respectively. Among those who were not the medical radiation technologists, however, they had absolutely no learning experience about the dental radiology in their school curricula and in their continuing education courses (Table 3).

Cognition for the concepts of dental radiology after this dental radiology course for the continuing education of medical radiation technologists

There were 9 investigated questions for analyzing the participants' cognition for (1) the experience about the dental radiology courses, (2) the basic knowledge about the dental radiology, (3) the attitude towards the dental radiation protection and interest in further learning of the dental radiology, and (4) the personal viewpoint for this dental radiology course (Table 4).

According to the respondents' experience, most of them agreed that there are very few courses about the dental radiology in the medical radiation school curricula, and there are very few courses about the dental radiology in the continuing education courses. The mean scores for above two questions were 4.09 ± 0.75 and 3.94 ± 0.78, respectively. The numbers (rates) of respondents who answered as agree were 69 (81.18%) and 65 (76.47%), respectively (Table 4). Moreover, most of the participants found this dental radiology course to be helpful in raising their basic knowledge about the dental radiology and radiation protection, their attitude towards the dental radiology, and their interest in further learning of the dental radiology. They also agreed that the course was helpful for the works and they were satisfied with this course. The degree of agreement for each question was high with the mean scores for each question being between 3.87 and 4.61. The numbers (rates) of respondents who answered as agree were between 58 (68.24%) and 84 (98.82%). Due to these mean scores were all more than 3, it meant that on average answerers agreed all the investigated questions (Table 4).

Comparisons of respondents' cognition for the concepts of dental radiology after this dental radiology course for the continuing education of medical radiation technologists

The differences in the mean scores of investigated questions were compared between male and female respondents, between those with less than 20 years of practice experience and those with more than 21 years of practicing experience, between those whose main working field was in the diagnostic radiology and those whose main working field was outside the diagnostic radiology, as well as between those with the medical radiation technologist certificates and those without the medical radiation technologist certificates (Tables 5–8).

For the comparison between male and female respondents, except for the question 2, all the mean scores for each question answered by the male respondents were higher than those answered by the female respondents. The difference in the mean score of question 9 was

Table 4 Question content and question type used in the questionnaire survey by the self-assessment of respondents' cognition for the concepts of dental radiology after finishing the dental radiology course for the continuing education of medical radiation technologists and the survey results.

Question content	Question type	Mean score ± SD	Number (rate) of respondents who answered as agree
1. Based on personal experience, there are very few courses of the dental radiology in the medical radiation school curricula.	For experience, multiple choice	4.09 ± 0.75	69 (81.18%)
2. Based on personal experience, there are very few continuing education courses of the dental radiology.	For experience, multiple choice	3.94 ± 0.78	65 (76.47%)
3. After participating in this course, I consider that the course content helps me understand the principles and techniques of dental radiography.	For knowledge, multiple choice	4.46 ± 0.52	84 (98.82%)
4. After participating in this course, I consider that the course content helps me understand the radiation protection in dental radiography.	For knowledge, multiple choice	4.49 ± 0.53	84 (98.82%)
5. The radiation workers need to have good radiology techniques (including dental radiology techniques) to reduce unnecessary re-irradiation, which can reduce the radiation exposure dose of the patients and the environment, to comply with the principle of as low as reasonably achievable (ALARA).	For attitude, multiple choice	4.61 ± 0.51	84 (98.82%)
6. I am interested in learning about advanced dental radiology techniques, such as the operating techniques of cone-beam computed tomography (CBCT) and its radiation parameter settings for various dental diseases.	For attitude, multiple choice	4.15 ± 0.75	69 (81.18%)
7. After participating in this course, I consider that dental radiology is also one of the options suitable for the career development as a medical radiation technologist.	For attitude, multiple choice	4.28 ± 0.63	77 (90.59%)
8. Overall, this course is helpful for the works.	For viewpoint, multiple choice	3.87 ± 0.83	58 (68.24%)
9. Overall, I am satisfied with this course.	For viewpoint, multiple choice	4.48 ± 0.57	82 (96.47%)

Table 5 Comparison of respondents' cognition for the concepts of dental radiology between male and female respondents after finishing the dental radiology course for the continuing education of medical radiation technologists.

Questions	Male (n = 30)		Female (n = 55)		*t-test*
	Mean score ± SD	Number (rate) of respondents who answered as agree	Mean score ± SD	Number (rate) of respondents who answered as agree	*P*-value
Question 1	4.17 ± 0.79	25 (83.33%)	4.05 ± 0.73	44 (80%)	0.257
Question 2	3.93 ± 0.87	22 (73.33%)	3.95 ± 0.73	43 (78.18%)	0.473
Question 3	4.50 ± 0.51	30 (100%)	4.44 ± 0.54	54 (98.18%)	0.298
Question 4	4.57 ± 0.50	30 (100%)	4.45 ± 0.54	54 (98.18%)	0.175
Question 5	4.63 ± 0.49	30 (100%)	4.60 ± 0.53	54 (98.18%)	0.388
Question 6	4.17 ± 0.83	24 (80%)	4.15 ± 0.70	45 (81.82%)	0.451
Question 7	4.37 ± 0.67	27 (90%)	4.24 ± 0.61	50 (90.91%)	0.182
Question 8	3.97 ± 0.85	21 (70%)	3.82 ± 0.82	37 (67.27%)	0.216
Question 9	4.63 ± 0.49	30 (100%)	4.40 ± 0.60	52 (94.55%)	0.035*

*$P < 0.05$.

significant ($P < 0.05$, Table 5). In the self-assessment of the male respondents after this dental radiology course, the degree of raising their basic knowledge about the dental radiology, their attitude towards the dental radiation protection, and their interest in further learning of the dental radiology was higher than that of the female respondents. Thus, the male respondents were more affirmed and satisfied with this dental radiology course than the female respondents (Table 5).

For the comparison between those with less than 20 years of practice experience and those with more than 21 years of practicing experience, except for questions 1 and 2, all the mean scores for each question of the respondents with more than 21 years of practicing experience were higher than those of the respondents with less than 20 years of practice experience. However, there were no significant differences in the mean scores (Table 6). In the self-assessment of the respondents with more senior practicing experience after this dental radiology course, the degree of raising their basic knowledge about the dental radiology, their attitude towards the dental radiation protection, and their interest in further learning of the dental radiology was higher than that of the respondents with more junior practicing experience, although these differences were not significant (Table 6).

For the comparison between those whose main working field was in the diagnostic radiology and those whose main working field was outside the diagnostic radiology, except for questions 1, 2 and 3, all the mean scores for questions of the respondents in the diagnostic radiology were higher than those of the respondents outside the diagnostic radiology. The difference in the mean score of question 8 was significant ($P < 0.01$, Table 7). In the self-assessment of those respondents in the diagnostic radiology after finishing the dental radiology course, the degree of raising their attitude towards the dental radiation protection, and their interest in further learning of the dental radiology was higher than that of those respondents outside the diagnostic radiology. Thus, those respondents in the diagnostic radiology were more affirmed and thought this dental radiology course would be helpful for their works (Table 7).

Table 6 Comparison of respondents' cognition for the concepts of dental radiology between those with less than 20 years of practice experience and those with more than 21 years of practicing experience after finishing the dental radiology course for the continuing education of medical radiation technologists.

Questions	Those with less than 20 years of practice experience (n = 59)		Those with more than 21 years of practicing experience (n = 26)		*t-test*
	Mean score ± SD	Number (rate) of respondents who answered as agree	Mean score ± SD	Number (rate) of respondents who answered as agree	*P*-value
Question 1	4.15 ± 0.74	49 (83.05%)	3.96 ± 0.77	20 (76.92%)	0.141
Question 2	3.97 ± 0.79	46 (77.97%)	3.88 ± 0.77	19 (73.08%)	0.329
Question 3	4.42 ± 0.53	58 (98.31%)	4.54 ± 0.51	26 (100%)	0.178
Question 4	4.44 ± 0.53	58 (98.31%)	4.62 ± 0.50	26 (100%)	0.080
Question 5	4.59 ± 0.53	58 (98.31%)	4.65 ± 0.49	26 (100%)	0.310
Question 6	4.10 ± 0.76	47 (79.66%)	4.27 ± 0.72	22 (84.62%)	0.172
Question 7	4.24 ± 0.65	52 (88.14%)	4.38 ± 0.57	25 (96.15%)	0.161
Question 8	3.78 ± 0.85	38 (64.41%)	4.08 ± 0.74	20 (76.92%)	0.064
Question 9	4.42 ± 0.59	56 (94.91%)	4.62 ± 0.50	26 (100%)	0.077

Table 7 Comparison of respondents' cognition for the concepts of dental radiology between those whose main working field was in the diagnostic radiology and those whose main working field was outside the diagnostic radiology after finishing the dental radiology course for the continuing education of medical radiation technologists.

Questions	Those whose main working field was in the diagnostic radiology (n = 48)		Those whose main working field was outside the diagnostic radiology (n = 37)		*t-test*
	Mean score ± SD	Number (rate) of respondents who answered as agree	Mean score ± SD	Number (rate) of respondents who answered as agree	*P*-value
Question 1	4.00 ± 0.80	37 (77.08%)	4.22 ± 0.67	32 (86.49%)	0.095
Question 2	3.88 ± 0.82	35 (72.92%)	4.03 ± 0.73	30 (81.08%)	0.187
Question 3	4.46 ± 0.54	47 (97.92%)	4.46 ± 0.51	37 (100%)	0.496
Question 4	4.50 ± 0.55	47 (97.92%)	4.49 ± 0.51	37 (100%)	0.454
Question 5	4.63 ± 0.53	47 (97.92%)	4.59 ± 0.50	37 (100%)	0.394
Question 6	4.21 ± 0.71	40 (83.33%)	4.08 ± 0.80	29 (78.38%)	0.220
Question 7	4.33 ± 0.60	45 (93.75%)	4.22 ± 0.67	32 (86.49%)	0.199
Question 8	4.06 ± 0.67	39 (81.25%)	3.62 ± 0.95	19 (51.35%)	0.007**
Question 9	4.50 ± 0.55	47 (97.92%)	4.46 ± 0.61	35 (94.59%)	0.373

**$P < 0.01$.

For the comparison between those with the medical radiation technologist certificates and those without the medical radiation technologist certificates, except for question 5, all the mean scores for each question of the respondents with the medical radiation technologist certificates were higher than those of the respondents without the medical radiation technologist certificates. The differences in the mean scores of questions 1 and 2 were significant ($P < 0.05$, Table 8). In the self-assessment of those respondents with the medical radiation technologist certificates after finishing this dental radiology course, the degree of raising their basic knowledge about the dental radiology, and their interest in further learning of the dental radiology was higher than that of those respondents without the medical radiation technologist certificates. Moreover, the medical radiation technologists were more likely to agree that there are very few dental radiology courses in the medical radiation school curricula and in the continuing education courses (Table 8).

Discussion

During the Japanese colonial period (1895—1945), the colonial government directly transplanted the modern dental system to Taiwan. According to the dentist-related laws and regulations at the time, the dental radiology was stipulated as one of the 11 dental professions as early as 1918 (Taisho 7).[5–7] This proves that the dental radiology has a long history in Taiwan. However, even though it has been a long time since the first dental school and the first medical radiation school were established in Taiwan in 1953 and 1965, respectively, a standardized dental radiology education system has not yet been developed.[6,8] The dental

Table 8 Comparison of respondents' cognition for the concepts of dental radiology between those with the medical radiation technologist certificates and those without the medical radiation technologist certificates after finishing the dental radiology course for the continuing education of medical radiation technologists.

Questions	Those with the medical radiation technologist certificates (n = 74)		Those without the medical radiation technologist certificates (n = 11)		*t-test*
	Mean score ± SD	Number (rate) of respondents who answered as agree	Mean score ± SD	Number (rate) of respondents who answered as agree	*P*-value
Question 1	4.16 ± 0.72	62 (83.78%)	3.64 ± 0.81	7 (63.64%)	0.015*
Question 2	4.00 ± 0.76	59 (79.73%)	3.55 ± 0.82	6 (54.55%)	0.035*
Question 3	4.47 ± 0.53	73 (98.65%)	4.36 ± 0.50	11 (100%)	0.261
Question 4	4.51 ± 0.53	73 (98.65%)	4.36 ± 0.50	11 (100%)	0.191
Question 5	4.61 ± 0.52	73 (98.65%)	4.64 ± 0.50	11 (100%)	0.433
Question 6	4.16 ± 0.72	60 (81.08%)	4.09 ± 0.94	9 (81.82%)	0.385
Question 7	4.28 ± 0.63	67 (90.54%)	4.27 ± 0.65	10 (90.91%)	0.479
Question 8	3.89 ± 0.82	51 (68.92%)	3.73 ± 0.90	7 (63.64%)	0.271
Question 9	4.49 ± 0.58	71 (95.95%)	4.45 ± 0.52	11 (100%)	0.432

*$P < 0.05$.

radiology as a common field of dentistry and medical radiology is an important portion for the dental practice. In Taiwan, the current dental schools and medical radiation schools do not provide an appropriate amount of dental radiology courses to their undergraduate students.[5,9]

In Taiwan, the formal national examination for licensing medical radiation technologists began in 1978, while the legal system of Medical Radiation Technologists Act (MRTA) was established in 2000.[10] According to the MRTA, the medical radiation technologies perform the following functions: (1) general radiography for the diagnostic radiology, (2) nuclear medical in-vitro examination, (3) special radiography and imaging for the diagnostic radiology, (4) radiotherapy, (5) imaging and in-vivo analysis and examination for the nuclear medical diagnosis, (6) nuclear medical therapy, (7) magnetic resonance imaging (MRI) and non-ionizing radiation imaging (such as ultrasound for bone mineral density test), and (8) other activities recognized by the central competent authority. Thus, the dental radiology was just a small item in the general radiography for the diagnostic radiology, resulting in the rare offer of the independent dental radiology courses in the medical radiation schools.[6]

According to Taiwan's current regulations on the continuing education for the medical personnel and radiation workers, the medical personnel, including the medical radiation technologists, should complete at least 120 points of continuing education courses every six years (usually one point for a 1-h course), while on-the-job radiation workers, also including the medical radiation technologists, should complete at least 3 h of radiation protection education and training every year. Thus, we designed this dental radiology course with the content of radiation protection to meet the continuing education requirements for the medical radiation technologists and radiation workers through the continuing education organized by the TCART. The participants' feedback on the dental radiology course after the class was also investigated. The results could be used as a reference for establishing medical radiation school curriculum standards for the dental radiology in the future. Overall, although the motivations of those who participated in this dental radiology course were mainly for accumulating the continuing education points, the motivations of those participants who were not the medical personnel were mainly for the interesting course topics, showing that the interesting topics are the focus of dental radiology course design under the continuing education system.

According to our previous survey, among all medical radiation works in Taiwan, the number of male workers was slightly more than that of female workers.[11] However, in this course, the number of female participants were much more than that of male participants, showing that female medical personnel might be more concerned about the radiation protection issues, even in the field of the dental radiology. In addition, among the participants, most of them were engaged in the diagnostic radiology, followed by the radiation therapy and the nuclear medicine. This was consistent with the distribution of the main working fields among all medical radiation works.[11]

The importance and usage of the dental radiology in dental procedures are increasing day by day, but the number of the medical radiation technologists who are engaged in the dental radiology is still low, while the amount of dental radiology courses offered to our medical radiation students has not increased.[6,7] Among the dental institutions in the early Taiwan, their dental X-ray machines were mainly and even only for periapical images. Currently, both the dental departments of hospitals and the dental clinics have various types of dental X-ray machines for periapical, bite-wing, occlusal, panoramic, and cephalometric radiographies. There are also dental X-ray machines for special dental radiographies, such as cone-beam computed tomography (CBCT), hand plate, temporomandibular joint (TMJ) and skull/maxillofacial radiographies in the dental departments of hospitals.[12] In addition, the CBCT is also gradually popularized in the general dental clinics.[13] Therefore, it is an expected trend that the dentists need the medical radiation technologists to assist professionally in their dental radiography work.

This study explored the participants' cognition for the concepts of dental radiology after the class through the questionnaire survey. The participants were mainly medical radiation technologists, followed by radiation protection personnel and medical staff. They generally agreed that there are very few courses of the dental radiology in the medical radiation school curricula and in the continuing education courses. This actually echoes another study of ours, showing that the dental radiology courses are rare in the dental school curricula and in the dentist continuing education.[14] In addition, most of the participants satisfied with this dental radiology course, and the course was found to be helpful in raising their basic knowledge about the dental radiology and radiation protection, their attitude towards the dental radiology, and their interest in further learning of the dental radiology. This also indicates that the participants are highly interested in the dental radiology course for their continuing education, and such courses attract their attention and potentially are helpful for their works.

In this study, the male participants had more positive feedback on the dental radiology course than the female participants, showing that the male participants are more confident in their self-assessment of the learning effectiveness of this course, especially the acquisition of relevant knowledge of dental radiology, and the recognition of dental radiology being also one of the options suitable for the career development as a medical radiation technologist. Among the respondents, those with the more senior practicing experience had more positive feedback on the dental radiology course, especially the agreement of this course being helpful for their works. Moreover, those whose main working field was in the diagnostic radiology had more positive feedback on the dental radiology course than those whose main working field was outside the diagnostic radiology. Those engaged in the diagnostic radiology also agreed that the dental radiology is also one of the options suitable for the career development as a medical radiation technologist, and this course is helpful for their works.

In addition, those with the medical radiation technologist certificates generally had more positive feedback on the dental radiology course than those without the medical radiation technologist certificates. Among these medical radiation technologists, they were more likely to agree that there are very few courses about the dental radiology in the

medical radiation school curricula and in the continuing education courses. The learning and working background may be the reason for the differences in the feedback on the dental radiology course between these participants in different groups. However, the above differences still need further researches to explore the reasons why we obtained these results.

Finally, the dental radiology course contributed to an increase in participants' basic knowledge of dental radiology, their awareness and understanding of the radiation protection in dental radiography, and the recognition of dental radiology being also one of the options suitable for the career development as a medical radiation technologist.

Especially, the male participants, those with more senior practicing experience, those engaged in the diagnostic radiology, and those with the medical radiation technologist certificates had more positive feedback on the dental radiology course. Considering the effectiveness of the course on the participants' basic knowledge and attitude about the dental radiology, this model shows promise for further use in the continuing education of medical radiation technologists. We believe that a comprehensive dental radiology education system shall be established in the future, including both the undergraduate courses for the medical radiation students and their continuing education. The advanced dental radiology courses designed for the medical radiation students and the postgraduate clinical training related to the dental radiology developed for the practicing medical radiation technologists should be considered. However, these require a long-term promotion. Nonetheless, a comprehensive dental radiology education system could open a new career option for the medical radiation students and a new practice direction for the practicing medical radiation technologists, expanding their potential involvement in the field of the dental radiology.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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