Journal of Dental Sciences 18 (2023) 1354–1360

Available online at www.sciencedirect.com

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journal homepage: www.e-jds.com

Original Article

A survey of the dental radiology course designed for dentist continuing education in Taiwan

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Received 30 April 2023; Final revision received 3 May 2023
Available online 14 May 2023

KEYWORDS
Dental radiology;
Dentist continuing education;
Dentists

Abstract *Background/purpose:* In Taiwan, dental radiology has a long history of development. However, there are very few dental radiology curricula in Taiwan's dental education system. This study explored preliminarily the dental radiology course designed for dentist continuing education in Taiwan.
Materials and methods: This study used the method of dental radiology education survey by questionnaire to evaluate participating dentists' learning outcomes by assessing their perceptions of the dental radiology course.

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https://doi.org/10.1016/j.jds.2023.05.004

Results: In this study, 117 participating dentists filled out the questionnaires completely after the class of dentist continuing education. The results showed that most of participating dentists agreed that dental radiology courses were rare in dental school curriculum and dentist continuing education. Moreover, most of participating dentists found this course to be helpful in raising their basic knowledge and skill about dental radiology, their attitude towards dental radiology, and their interest in further learning of dental radiology. They were satisfied with the course. The degree of agreement for each question was high, and all the mean scores for each question were between 4.53 and 4.77. The numbers (rates) of respondents who answered as agree were between 105 and 113 (between 89.74% and 96.58%).
Conclusion: The dental radiology course contributed to an increase in dentists' basic knowledge and skill about dental radiology and their awareness and understanding of the importance of dental radiology. Considering the effectiveness of the dental radiology course on dentists' basic knowledge/skill and attitude of dental radiology, this model shows promise for further use in dentist continuing education.

Introduction

Since Wilhelm Conrad Roentgen discovered X-rays in late 1895 and the German dentist Otto Walkhoff acquired an X-ray radiograph of his own teeth in early1896, the use of X-ray in medical photography for medicine and dentistry has spread around the world. Furthermore, a company now known as Siemens in Germany manufactured the first dental X-ray machine in 1905. Therefore, the dental radiology has been existed for over 120 years.[1—4]

There is a good proof that the article "the value of X-ray in the diagnosis of dental diseases (with photobook)" was published in the Journal of the Formosan Medical Association by the Taiwan Government Taipei Hospital in 1913.[5] This may be the earliest academic publication on the application of dental X-ray images for diagnosis of dental diseases in Taiwan. Therefore, the dental radiology in Taiwan also has a history of at least 100 years and is almost synchronized with the world.[6—8] Dental radiology has a long history of development, and this subject is also one of the important clinical and basic courses in the dental schools. It is very important for dental teaching, clinical diagnosis, and research. However, it does not take much weight in the six-year dental school study career of Taiwan's undergraduate dental students. There are usually only 2 credits of lectures and 2 credits of clinical practice.[9] Therefore, it is necessary for dentists to enrich their knowledge and skill related to 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 medical and dental radiation workers. In Taiwan, in addition to medical radiation technologists, dentists are the only personnel who can legally operate dental X-ray machines. Therefore, in a broad sense, dentists are also so-called radiation workers in IRPA. The Taiwan Dental Association (TWDA) designed a 3-h dental radiology online course for dentist continuing education for the first time in 2022, and provided free participation of this course for in-service dentists. The participating dentists responded well after the class of dentist continuing education. In 2023, the TWDA conducted this course for the second time.

This 3-h dental radiology online course introduced the concept of dental radiology to practicing dentists, and aimed to improve dentists' understanding of the growing relationship between dental procedures and dental radiography by introducing the dental radiology technology. The purpose of this study was to evaluate participating dentists' learning outcomes by assessing their perceptions of this course. Thus, the method of dental radiology education survey was used to find the opinions of participating dentists on dental radiology, and tried to analyze the differences in the opinions between two different groups of dentists. The results of this study would be used as a reference for the establishment of the dental radiology education system for dentist continuing education.

Materials and methods

Participants

All dentists who participated the dental radiology online course for dentist continuing education offered by the TWDA in 2023 were included in this study. Their gender, specialist qualification, dental institutions (hospitals or dental clinics), and practice registration place (or working place) were confirmed by the public inquiry system and were used as the basis for grouping of the participating dentists.

Teaching process

This course was a specific 3-h dental radiology online course for in-service dentists and was performed in the form of lectures. It was offered free of charge to the TWDA member dentists nationwide for dentist continuing education. The course content included the principles of dental radiography, the techniques to assemble dental radiography instruments, and the methods to correct errors in dental

radiography. It was performed by the senior medical radiation technologist in the Department of Dentistry of National Taiwan University Hospital (NTUH). All dentists who signed up for this dental radiology course would receive an online course link sent by the TWDA through email before the class, and all dentists who participated this dental radiology course would also receive an online questionnaire link after the class of this dentist continuing education.

Survey tool

All dentists who participated this dental radiology course were invited to fill out the questionnaire for the dental radiology education survey after the class of dentist continuing education. The purpose of this survey was for analyzing the participants' cognition for 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 dental radiology. 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 for dental radiology learning (questions 1 and 2), (2) the self-assessment of participants' cognition for knowledge and skill about dental radiology (questions 3, 4 and 5), (3) the attitude towards dental radiology and interest in further learning of dental radiology (questions 6, 7 and 8), and (4) personal viewpoint for this dental radiology course (questions 9 and 10).

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 participating dentists were suggested to fill the score or answer in fresh memory.

Statistical analysis

All data obtained from the participating dentists 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 dentists 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 119 dentists who completed the dental radiology online course for dentist continuing education offered by the TWDA in 2023 were included in this study. Among them, 117 participating dentists filled out the questionnaires completely after the class of dentist continuing education. The valid response rate was 98.32%. Of these 117 dentists, there were 79 (67.52%) males and 38 (32.48%) females. For specialist qualification, there were 57 (48.72%) dental specialists and 60 (51.28%) general dentists. For dental institutions, there were 25 (21.37%) hospital dentists and 92 (78.63%) clinic dentists. In addition, the participating dentists were mainly from cities (85, 72.65%) and western region of Taiwan (103, 88.03%), while those from municipalities (57, 48.72%) or non-municipalities (60, 51.28%) were comparable (Table 1).

Table 1 Distribution of dentists (n = 117) who completed the online course of dental radiology technology for dentist continuing education offered by the Taiwan Dental Association (TWDA) in 2023.

Category	Number (proportion) of dentists	
Gender	Male	Female
	79 (67.52%)	38 (32.48%)
Specialist qualification	Dental specialists	General dentists
	57 (48.72%)	60 (51.28%)
Dental institutions	Hospitals	Dental clinics
	25 (21.37%)	92 (78.63%)
Practice registration place (or working place)	Municipalities	Non-municipalities
	57 (48.72%)	60 (51.28%)
	Cities	Counties
	85 (72.65%)	32 (27.35%)
	Western region	Eastern region and outlying islands
	103 (88.03%)	14 (11.97%)

The dentists' cognition for concepts of dental radiology after the class of dentist continuing education

There were 10 investigated questions for analyzing participating dentists' cognition for (1) the experience for dental radiology learning, (2) the basic knowledge and skill about dental radiology, (3) the attitude towards dental radiology and interest in further learning of dental radiology, and (4) personal viewpoint for this dental radiology course after the class of dentist continuing education (Table 2).

According to respondents' experience, most of participating dentists agreed that dental students were not adequately taught the dental radiology course in their dental school curriculum, and there are very few courses of dental radiology technology for dentist continuing education. The mean scores for above questions were 3.70 ± 1.06 and 3.97 ± 0.93, respectively. The numbers (rates) of respondents who answered as agree were 70 (59.83%) and 82 (70.09%), respectively (Table 2). Moreover, most of the participating dentists found this dental radiology course to

Table 2 Question content and question type used in the survey by the self-assessment of dentists' cognition for concepts of dental radiology after the class of dentist continuing education and the survey results.

Question content	Question type	Mean score ± SD	Number (rate) of respondents who answered as agree
1. I consider that dental students are not adequately taught dental radiology in their school curriculum.	For experience, multiple choice	3.70 ± 1.06	70 (59.83%)
2. I consider that there are very few courses on dental radiology technology in dentist continuing education.	For experience, multiple choice	3.97 ± 0.93	82 (70.09%)
3. After participating in this course, the course content helps me understand the principles of dental radiography.	For knowledge, multiple choice	4.68 ± 0.58	112 (95.73%)
4. After participating in this course, the course content improves my technical ability to assemble dental radiography instruments.	For skill, multiple choice	4.53 ± 0.74	105 (89.74%)
5. After participating in this course, the course content helps me understand how to correct errors in dental radiography.	For skill, multiple choice	4.68 ± 0.63	112 (95.73%)
6. Dentists need to have good dental radiology techniques to reduce unnecessary re-irradiation, which can reduce the radiation exposure dose of patients and the environment, to comply with the principle of ALARA (as low as reasonably achievable).	For attitude, multiple choice	4.76 ± 0.60	112 (95.73%)
7. Dental radiography is an important method for disease diagnosis and treatment evaluation in the dental procedure. Improving dentists' knowledge and skill about dental radiography will help dentists perform dental procedure.	For attitude, multiple choice	4.71 ± 0.66	109 (93.16%)
8. I am interested in learning about advanced dental radiology techniques, such as the operating techniques of cone-beam computerized tomography (CBCT).	For attitude, multiple choice	4.54 ± 0.73	106 (90.60%)
9. Overall, this course is helpful for work.	For viewpoint, multiple choice	4.73 ± 0.60	113 (96.58%)
10. Overall, I am satisfied with this course.	For viewpoint, multiple choice	4.77 ± 0.58	113 (96.58%)

be helpful in raising their basic knowledge and skill about dental radiology, their attitude towards dental radiology, and their interest in further learning of dental radiology. They also agreed that the course was helpful for dental work and they were satisfied with the course. The degree of agreement for each question was high, and all the mean scores for each question were between 4.53 and 4.77. The numbers (rates) of respondents who answered as agree were between 105 and 113 (between 89.74% and 96.58%). Due to these mean scores were all more than 3, it meant that on average answerers agreed all the investigated questions (Table 2).

The comparisons of dentists' cognition for concepts of dental radiology after the class of dentist continuing education

The differences in the mean scores of investigated questions were compared between male and female dentists, between dental specialists and general dentists, between hospital dentists and clinic dentists, as well as between dentists from cities and dentists from counties (Tables 3–6). For the comparison between male and female dentists, except for question 1, all the mean scores for each question answered by female dentists were higher than those answered by male dentists. The differences in the mean scores of question 3 ($P < 0.01$), and questions 5, 6, 9 and 10 ($P < 0.05$) were significant between male and female dentists (Table 3). In the self-assessment of female dentists after class of dentist continuing education, the degree of this course raising their basic knowledge and skill about dental radiology, their attitude towards dental radiology, and their interest in further learning of dental radiology was higher than that of male dentists. Thus, female dentists are more affirmed and satisfied with this course than male dentists.

For the comparison between dental specialists and general dentists, all the mean scores for each question of general dentists were higher than those of dental specialists. The difference in the mean score of question 9 ($P < 0.05$) was significant (Table 4). In the self-assessment of general dentists after the class of dentist continuing education, the degree of this course raising their basic knowledge and skill about dental radiology, their attitude towards dental radiology, and their interest in further learning of dental radiology was higher than that of dental specialists, although these differences were not significant. General dentists are more likely to agree that this course is helpful for dental work than dental specialists.

For the comparison between hospital dentists and clinic dentists, all the mean scores for each question of hospital dentists were higher than those of clinic dentists (Table 5). In the self-assessment of hospital dentists after the class of dentist continuing education, the degree of this course raising their basic knowledge and skill about dental

Table 3 The comparison of dentists' cognition for concepts of dental radiology between male and female dentists after the class of dentist continuing education.

Questions	Male (n = 79)		Female (n = 38)		*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	3.73 ± 0.96	48 (60.76%)	3.63 ± 1.26	22 (57.89%)	0.313
Question 2	3.94 ± 0.91	57 (72.15%)	4.03 ± 0.97	25 65.79%)	0.313
Question 3	4.59 ± 0.65	74 (93.67%)	4.87 ± 0.34	38 (100%)	0.008**
Question 4	4.46 ± 0.80	69 (93.24%)	4.68 ± 0.57	36 (94.74%)	0.059
Question 5	4.59 ± 0.71	74 (93.67%)	4.84 ± 0.37	38 (100%)	0.023*
Question 6	4.70 ± 0.69	74 (93.67%)	4.89 ± 0.31	38 (100%)	0.046*
Question 7	4.65 ± 0.73	72 (91.14%)	4.84 ± 0.44	37 (97.37%)	0.065
Question 8	4.48 ± 0.80	69 (93.24%)	4.66 ± 0.53	37 (97.37%)	0.109
Question 9	4.66 ± 0.68	75 (94.94%)	4.87 ± 0.34	38 (100%)	0.037*
Question 10	4.70 ± 0.67	75 (94.94%)	4.92 ± 0.27	38 (100%)	0.024*

*$P < 0.05$, **$P < 0.01$.

Table 4 The comparison of dentists' cognition for concepts of dental radiology between dental specialists and general dentists after the class of dentist continuing education.

Questions	Dental specialists (n = 57)		General dentists (n = 60)		*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	3.63 ± 1.05	33 (57.89%)	3.79 ± 1.14	37 (61.67%)	0.305
Question 2	3.92 ± 0.94	39 (68.42%)	4.00 ± 0.93	43 (71.67%)	0.273
Question 3	4.61 ± 0.72	52 (91.23%)	4.76 ± 0.43	60 (100%)	0.057
Question 4	4.50 ± 0.86	50 (87.72%)	4.63 ± 0.63	55 (91.67%)	0.212
Question 5	4.66 ± 0.78	52 (91.23%)	4.79 ± 0.41	60 (100%)	0.053
Question 6	4.68 ± 0.77	53 (92.98%)	4.82 ± 0.46	59 (98.33%)	0.089
Question 7	4.63 ± 0.82	52 (91.23%)	4.76 ± 0.54	57 (95%)	0.107
Question 8	4.53 ± 0.83	52 (91.23%)	4.61 ± 0.72	54 (90%)	0.247
Question 9	4.63 ± 0.79	53 (92.98%)	4.84 ± 0.37	60 (100%)	0.047*
Question 10	4.66 ± 0.78	54 (94.74%)	4.92 ± 0.27	59 (98.33%)	0.110

*$P < 0.05$.

Table 5 The comparison of dentists' cognition for concepts of dental radiology between hospital and clinic dentists after the class of dentist continuing education.

Questions	Hospital dentists (n = 25)		Clinic dentists (n = 92)		*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	3.76 ± 0.93	15 (60%)	3.68 ± 1.10	55 (59.78%)	0.377
Question 2	4.08 ± 0.86	19 (76%)	3.93 ± 0.95	63 (68.48%)	0.245
Question 3	4.76 ± 0.60	23 (92%)	4.66 ± 0.58	89 (96.74%)	0.231
Question 4	4.60 ± 0.65	23 (92%)	4.51 ± 0.76	82 (89.13%)	0.297
Question 5	4.68 ± 0.63	23 (92%)	4.67 ± 0.63	89 (96.74%)	0.483
Question 6	4.84 ± 0.47	24 (96%)	4.74 ± 0.63	88 (95.65%)	0.228
Question 7	4.80 ± 0.50	24 (96%)	4.68 ± 0.69	85 (92.39%)	0.220
Question 8	4.60 ± 0.58	24 (96%)	4.52 ± 0.76	82 (89.13%)	0.317
Question 9	4.76 ± 0.60	23 (92%)	4.72 ± 0.60	90 (97.83%)	0.376
Question 10	4.88 ± 0.44	24 (96%)	4.74 ± 0.61	89 (96.74%)	0.141

Table 6 The comparison of dentists' cognition for concepts of dental radiology between dentists from cities and dentists from counties after the class of dentist continuing education.

Questions	Dentists from cities (n = 85)		Dentists from counties (n = 32)		*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	3.72 ± 1.04	49 (57.65%)	3.66 ± 1.12	21 (66.63%)	0.391
Question 2	3.99 ± 0.92	58 (68.24%)	3.91 ± 0.96	24 (75%)	0.336
Question 3	4.73 ± 0.50	83 (97.65%)	4.56 ± 0.76	29 (90.63%)	0.084*
Question 4	4.59 ± 0.64	78 (91.76%)	4.38 ± 0.94	27 (84.38%)	0.082*
Question 5	4.74 ± 0.49	83 (97.65%)	4.50 ± 0.88	29 (90.63%)	0.032*
Question 6	4.85 ± 0.39	84 (98.82%)	4.53 ± 0.92	28 (87.5%)	0.005**
Question 7	4.78 ± 0.52	81 (95.29%)	4.53 ± 0.92	28 (87.5%)	0.036*
Question 8	4.62 ± 0.62	79 (92.94%)	4.31 ± 0.93	27 (84.38%)	0.019*
Question 9	4.76 ± 0.48	83 97.65%)	4.63 ± 0.83	30 (93.75%)	0.130
Question 10	4.76 ± 0.50	82 (96.47%)	4.78 ± 0.75	31 (96.88%)	0.445

*$P < 0.05$, **$P < 0.01$.

radiology, their attitude towards dental radiology, and their interest in further learning of dental radiology was higher than that of clinic dentists, although the differences in the mean scores of all investigated questions were not significant.

For the comparison between dentists from cities and dentists from counties, except for question 10, all the mean scores for each question of dentists from cities were higher than those of dentists from counties. The differences in the mean scores of question 6 ($P < 0.01$), and questions 3, 4, 5, 7 and 8 ($P < 0.05$) were significant (Table 6). In the self-assessment of dentists from cities after the class of dentist continuing education, the degree of this course raising their basic knowledge and skill about dental radiology, their attitude towards dental radiology, and their interest in further learning of dental radiology was higher than that of dentists from counties. Therefore, dentists from cities are more likely to agree that this course is helpful for dental work than dentists from counties.

Discussion

Dental radiology has a long history in Taiwan. During the Japanese colonial period (1895–1945), the colonial government directly transplanted modern dental system to Taiwan. According to the dentist-related laws and regulations at that time, as early as 1918 (Taisho 7), it was stipulated that dental X-ray was one of 11 dental professions. After the 1920s, Taiwan's dentists in hospitals or dental clinics might already use dental X-ray equipment for their practice.[6–8] The article "the dental X-ray photography technology" was published in the Journal of the Taiwan Radiology Association by the Radiology Department of Taiwan Government Tainan Hospital in 1932.[10] To the best of our knowledge, this may be the earliest academic publication on dental X-ray photography technology in Taiwan. However, even though it has been 70 years since the first dental school was established in Taiwan in 1953, a standardized dental radiology education system has not yet been developed.[11]

Dental radiology is an important portion for dental practice. In Taiwan, the current dental education system does not provide an appropriate amount of dental radiology courses to undergraduate dental students. Although the dental school of National Taiwan University (NTU) first offered a one-credit dental radiology course in 1960, after more than 60 years of development, current dental students only take a two-credit dental radiology course which is mainly a lecture course for dental diagnosis, and a two-credit dental radiology clinical internship for more hands-on course in dental X-ray photography.[8,9] The early dental X-ray machines in Taiwan are mainly for periapical images. Currently, both the dental departments of hospitals and 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 computerized tomography (CBCT), hand plate, temporomandibular joint (TMJ) and skull/maxillofacial radiographies in the dental departments of hospitals. In addition, the CBCT is also gradually popularized in general dental clinics.[8] The importance and usage of dental radiology in dental procedures are increasing day by day, but the amount of dental radiology courses offered to our dental students has not increased.

The Taiwan Academy of Oral and Maxillofacial Radiology (TAOMR), established in 2000, aims to promote the research, teaching, and clinical training of oral and maxillofacial radiology, as well as to promote the specialist system of oral and maxillofacial radiology. This indicates that dentists in Taiwan have noticed the importance of establishing a comprehensive dental radiation education system. However, this involves undergraduate dental courses and postgraduate clinical training, which requires a long-term promotion to carry it out.

For the first time in 2022, the TWDA provided the free dental radiology online course for in-service dentists under the dentist continuing education system, and received good feedback from participating dentists. The TWDA continued to run the same course in 2023, while this study explored participating dentists' cognition for concepts of dental radiology after the class through questionnaires. The participating dentists generally agreed that dental students were not adequately taught the dental radiology in their

dental school curriculum and there were very few courses on dental radiology technology in the dentist continuing education. This indeed echoes the fact that dental radiology courses are rare in dental school curriculum and dentist continuing education in Taiwan. In addition, most of the participating dentists satisfied with the dental radiology course, and found the course to be helpful in raising their basic knowledge and skill about dental radiology, their attitude towards dental radiology (such as the concept of radiation protection and the importance of dental radiology for dental procedures), and their interest in further learning of dental radiology, such as the operating techniques for CBCT. This also indicates that dentists are highly interested in dental radiology for their continuing education, and such courses are practical for their dental work.

In this study, female dentists had more positive feedback on the dental radiology course than male dentists, showing that female dentists pay more attention to the concepts of dental radiology, especially the acquisition of relevant knowledge and skills, and the recognition of radiation protection for dental radiology. General dentists had more positive feedback on the dental radiology course that was helpful for dental work than dental specialists. Moreover, dentists from cities had more positive feedback on the dental radiology course than dentists from counties. In addition, hospital dentists had more positive feedback on the dental radiology course than clinic dentists, although there was no significant difference. Our past studies found that the average numbers of dentists in each hospital and clinic in Taiwan in 2019 are 10.77 and 1.88, respectively. Moreover, almost all clinic dentists operated dental radiology independently without relying on the assistance of medical radiation technologists.[12,13] This may be the reason for the difference in the feedback on the dental radiology course between hospital and clinic dentists. 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 dentists' basic knowledge and skill of dental radiology as well as their awareness and understanding of the importance of dental radiology. Especially, female dentists, general dentists and dentists from cities had more positive feedback on the dental radiology course. Considering the effectiveness of the course on dentists' basic knowledge/skill and attitude of dental radiology, this model shows promise for further use in dentist continuing education. We believe that a comprehensive dental radiology education system shall be established in the future, including both the undergraduate dental courses for dental students and the postgraduate clinical training for practicing dentists. The advanced dental radiology courses designed for dental students and the specialist system of dental radiology developed for postgraduate clinical training shall be considered. However, these require a long-term promotion. Nonetheless, a comprehensive dental radiology education system could open a new career option for dental students and a new practice direction for practicing dentists, expanding their potential involvement in the field of dental radiology.

Declaration of competing interest

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

Acknowledgments

None.

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