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Research Article

Effectiveness of Digital Radiography Training among Dental School Graduates

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Abstract

Purpose: With the rapid evolution of new technologies utilized in dental practice, digital radiography instruction has become essential in dental school curricula. There are many challenges in teaching radiology, including lack of available advanced technology and qualified radiology faculty. The purpose of this study was to determine the usefulness of digital radiography technology in radiology courses to improve student learning outcomes and satisfaction.

Methods: A 20-question survey was sent to dental and dental hygiene alumni (N = 420) from 2008-2011. In addition to demographic information and current use of digital or film radiography, the survey asked respondents to indicate whether the technology incorporated into the dental curriculum augmented clinical practice after matriculation from the dental program.

Results: Of 420 mailed-out surveys, 199 responses were received with a 47.4% response rate. Ninety-seven percent indicated that they currently use or plan to utilize digital radiography in their practice. The majority (60.0%) of respondents used the solid state digital system i.e. charged couple device and 25.2% used Photostimulable Phosphor Plates. An overwhelming number of respondents (94.5%) agreed that the radiology didactic, pre-clinical and clinical training they received in the received in a dental school setting influenced their current radiology practice.

Conclusion: In this study, alumni responses towards the incorporation of the technological enhancement in the radiology courses in the dental school curriculum provided evidence of the improved teaching effectiveness. This allowed ambivalence with both film and digital radiography in clinical practice. These results suggest that the incorporation of the most widely adopted technology was effective in preparing the alumni for effective use in private practice.

Keywords: *Radiography; Digital Imaging; Education; Dental*

Abbreviations

PSP: Photo Stimulable Phosphor

Introduction

Film-based radiography has been the most conventional and traditional method used to acquire images in dentistry [1]. Radiology is one of the main courses taught to students in the dental professional programs in the United States and Canada. Different instructional approaches have been utilized for teaching radiology in the dental school curriculum [2]. Exposing and processing film based images is part of the pre-clinical radiology training amongst dental and allied dental health students. Films are still being used, though less commonly, in dental practice since it is cost-effective, time-tested and is easier to archive images. The image quality from film-based radiography is comparable with that of digital images [3-6]. However, films have to be processed in chemical solutions (developer and fixer) which are toxic to the environment. Film based images could be misplaced while in transit. Also, it is difficult, but not improbable, to incorporate film-based images into electronic patient records [7-11].

Today, digital radiography is being adopted in many dental schools and in private dental practice settings [12-16]. Approximately 25% of dental schools and 30% of private dental offices have switched from film to digital radiographic systems [17,18]. The radiology curriculum at most dental schools has also been revised to include topics in digital radiography, including but not limited to principles, types, acquisition methods, advantages and disadvantages. Preclinical courses in dental radiography are delivered during the second year of the dental school curriculum [2]. The concurrent application of digital radiographic techniques in the radiology clinics has two logistic concerns. First, potential problems could arise if there is sudden loss of data due to server disruptions, or if a student inadvertently deletes an image, even though actual image data might not be completely lost. Secondly, students who graduate with training in digital radiography might seek employment in dental settings which are primarily film-based [19-21]. A few dental schools have avoided these issues by keeping the film-based system alive for an anticipated breakdown of the digital system and also to demonstrate to the students how films are processed and images viewed. Another issue facing most dental schools is the knowledge and ability of dental school faculty to teach digital radiography since this technology is relatively new. Maxillofacial radiologists trained from newer residency programs who serve as radiology faculty in select dental schools are imparting the necessary high-quality instruction [22].

The switch to digital radiographic systems in most dental settings has necessitated adequate didactic information on various radiographic systems be conveyed to students who will ultimately be the end-users of this technology [23-30]. The purpose of this study was to determine the effectiveness of training in digital systems and its impact on a day-to-day clinic practice setting and how radiographic systems enrich the educational experience imparted in a dental school setting. This was assessed by obtaining graduates' perceptions regarding their learning experience.

Methods

Radiology instruction is given to first year dental students over the course of the fall and spring semester. The radiology clinic is equipped with digital radiography indirect systems; Photo stimulable Phosphor (PSP) plates (*Gendex*, Hatfield, PA.) and Scan-X (*Air-Techniques Inc*., NY, USA) to scan the PSP plates.

Participants

Dental, dental hygiene graduates and residents (Periodontics, Endodontics and Advanced Education in General Dentistry) across academic years from 2008 through 2011, a total of 199 alumni, participated. The selection of graduates from these classes was based on having had didactic, pre-clinical and clinical training in digital radiography after the school transitioned from film to digital radiography in 2008. The study was approved by the University of Detroit Mercy Institutional Review Board for protection of Human Subjects (Protocol #:1112-46) and an exempt status was granted. All relevant contact information of alumni was obtained from the alumni relations office at the University of Detroit Mercy School of Dentistry after prior consent was obtained from administrative authorities.

Survey

A comprehensive review of the literature relevant to the pedagogy of digital radiography technology in the classroom was conducted to determine valid items for inclusion in this survey. The initial statements were carefully calibrated and all questions were means-tested by a panel of dental educators and students to provide feedback to create the final survey. The survey was created through Survey Gizmo (www.surveygizmo.com), an online, web-based, data collection and integration tool.

Initially, a hyperlink to the survey was sent out electronically to the graduates through the school wide email system. A cover letter was attached indicating the last date for completion and return of the survey. After the last date for return of survey lapsed, it was determined that the response rate was not adequate, therefore, a copy of the survey was printed and distributed through mail (USPS) to the generated list of alumni who had still not completed the survey. An email reminder was sent to those who had not responded to the survey requesting them to complete the survey and return by mail. An option was not given to respondents to complete the survey electronically. Questionnaires that were received were collected, sorted and compiled.

A total of 20 questions on diverse topics were included under five categories: (A) demographics, transition and adaptation, (B) knowledge of principles, (C) handling of sensors used in digital radiography, (D) viewing and interpreting digital images, (E) detecting and trouble-shooting errors. Category (A) included questions relating to demographic information, current designation and the current digital system used by alumni. Category (B) included questions regarding the aptitude of alumni in the area of digital radiography including level of training as obtained through dental school education and also the expertise of faculty. Category (C) included questions pertaining to the appropriate handling of digital radiographic sensors. Category (D) included questions to determine if alumni are interpreting radiographs using appropriate methods and armamentarium. Category (E) included items to determine if alumni were capable of identifying errors on radiographs and trouble-shooting, in their present practice scenarios. The items pertaining to the digital radiography education utilized a 5-point Likert-scale (strongly agree to strongly disagree). There were no questions for which open-ended responses were solicited.

Data Analysis

For analysis of the qualitative data, descriptive statistics (frequency and percent) was used to show the graduates' perceived efficacy of the teaching methods.

Results

Participants were asked to complete the survey regarding their educational experience with the use of digital radiography equipment as part of their training. A total of 199 alumni (47.4 %) completed the survey. Demographic information including gender (male/female), program and year attended are are illustrated in Table I. Briefly, 76 (38.2%) were male and 123 (61.8%) were female. Of the survey respondents who were DDS alumni, 97 (48.7%) were employed in the capacity of associate dentist, 24 (12.1%) owned a practice and 20 (10.1%) of the respondents stated that they were in a residency program. Of the DH alumni 58 (29.1% of the total respondents) worked as a dental hygienist. Regarding the number of years in practice, 25.1% had been in private practice at least one year, 37.2% of alumni were one to two years in practice and 37.7% of the respondents were within three to five years.

	Frequency	Percent (%)
Gender		
Male	76	38.2
Female	123	61.8
Years in Practice		
0-1 year	50	25.1
1-2 years	74	37.2
3-5 years	75	37.7
Current Position		
Associate	97	48.7
Owner	24	12.1
Hygienist	58	29.1
Assistant	0	0
Resident	20	10.1
Total Responses	199	47.4*

Table 1: *Demographics, years in practice and current positions of respondents.*

**The survey was sent out to 420 alumni out of whom 199 responded.*

Radiographic techniques utilized in the respondents' current practice and plans for incorporating digital imaging are shown in Table 2. The responses from participants who neither agreed nor disagreed (neutral) were not included. A majority of the respondents reported that they are currently using digital radiography. One hundred and twenty (60.3%) of participants in this survey used a solid-state direct digital system such as the CCD (Charged Couple Device). Fifty of the respondents (25.1%) used an indirect digital system such as PSP (Photo stimulable Phosphor Plate) and 73 respondents (36.7%) used traditional radiographic film in their practice. Of the respondents who were not using digital radiography at the time of the survey, 23.6% plan on incorporating digital radiography in the future, in their respective practices. In their scope of practice, 84.9% indicated that a dental assistant was responsible for exposing and processing radiographs, 50.3% acquired the radiographs themselves, 45.7% indicated that a dental hygienist obtained radiographs and 3.5% indicated that radiography was performed by the overseeing dentist. It is interesting to note that even though DDS and DH alumni are adequately trained to obtain radiographs themselves, the work was delegated most of the time. In all cases, there were 3% who do not plan on using digital radiography.

	Frequency	Percent (%)
Personnel responsible for radiograph acquisition		
Myself (respondent)	100	50.3
Assistant	169	84.9
Hygienist	91	45.7
Overseeing DDS	7	3.5
Radiography technique currently utilized		
Conventional film	73	36.7
CCD	120	60.3
PSP	50	25.1
Digital radiography in practice		
Currently using digital radiography	146	73.4
Does not plan on using digital radiography	6	3.0
Plans on using digital radiography in future	47	23.6

Table 2: *Radiography techniques utilized in current/future practice of respondents.*

Participants were asked if their overall didactic radiology and practical digital imaging educational training was adequate in preparing them for the future (Figure 1). It should be noted that 181 (91%) agreed or strongly agreed that the overall training in digital imaging prepared them in performing digital imaging procedures in practice. 94.5% of respondents strongly agreed/agreed that radiology faculty were adequately trained to teach digital imaging in a didactic setting to students in both pre-clinic and clinic to keep in tune with the current digital radiographic techniques in the realm of private practice. Participants were asked if during instruction faculty follow proper protocol and strive to produce high quality images and are able to display consistency in producing digital images. The majority of the responses 94.5% strongly agreed/agreed that proper and consistent protocol was followed and that radiology faculty strive to obtain high quality digital images with the radiographic techniques available in the clinics.

The survey also included questions pertaining to comparisons between digital and traditional film radiography. Respondents were asked for their opinion about the handling properties, accuracy, lighting for proper interpretation and amount of radiation exposure of digital radiographic sensors, particularly; PSP plates over conventional radiographic film (Table 3). One hundred and fifty-seven (78.9%) of respondents confirmed that the handling properties of PSP are better than film whereas 21.1% indicated that conventional radiographic film was better than PSP plates. An elaborate comment section on the reasons to why respondents voted for one kind of sensor to be better than the other was not included in the questionnaire. Furthermore, when respondents were asked for their expertise with damages to PSP plates or sensors, 51.3% answered in the affirmative and 35.2% responded in the negative.

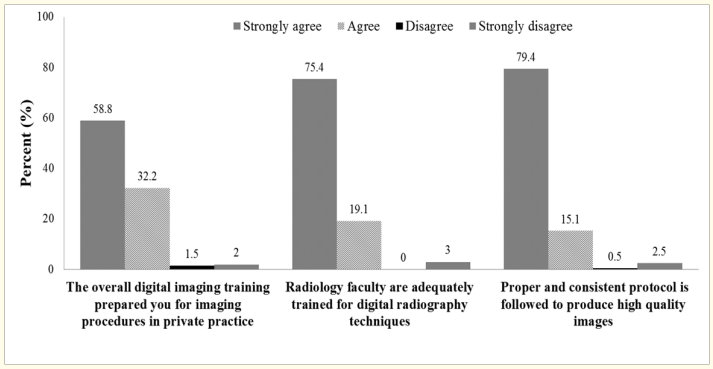

Figure 1: *Survey responses on radiology and digital imaging instruction at UDM School of Dentistry.*

	Frequency	Percent (%)
Are the handling properties for PSP plates for intraoral imaging better than film?		
Yes	157	78.9
No	42	21.1
Which system is better for making an accurate diagnosis of caries and periodontal disease based on your personal experience?		
Digital	160	80.4
Film	39	19.6
Do you have the recommended lighting available to you for proper interpretation of radiographs?		
Yes	111	55.8
No	46	23.1
I don't know	42	21.1
Do you think the amount of radiation exposure in digital radiography is less than, greater than or equal to the amount of radiation exposure in conventional film based radiography?		
Less	170	85.4
Greater	3	1.5
Equal	26	13.1

Table 3: *Digital radiography compared to traditional radiography.*

In order to gain insight into the maintenance of PSP plates, respondents were asked to indicate their preferred method of disinfection of sensors after each use and after repeated exposure of those plates. Cavi-wipe disinfectants, cavicide disinfectant spray, disinfectant wipe and disinfectant spray were used by 79.9%, 11.6% 7.5% and 6.5%, respectively.

The final set of questions was targeted at assimilating information on respondent's knowledge of the diagnostic capabilities of digital sensors. Diagnostic accuracy of PSP plates compared to film in detecting caries and periodontal disease was assessed. The majority of the respondents (80.4%) indicated that digital sensors are superior in allowing accurate diagnosis of caries and periodontal disease, whereas, 19.6% indicated film was better in detecting caries and periodontal disease. Appropriate ambient lighting is an important factor that can confound accurate diagnosis on radiographic images. Respondents were questioned about the lighting conditions and location(s) where the radiographic images are viewed and interpreted. A designated chair-side viewing area for radiographic diagnosis was utilized by 84.9%, whereas 34.2% indicated the use of a dark room for viewing radiographs. With reference to viewing conditions, 74.4% of

respondents mentioned they use LCD (Liquid Crystal Display) monitors to view radiographic images of their patients. 32.2% of them reported that laptop screen use to view radiographs and 6.5% use CRT (Cathode Ray Tube) monitors for similar purposes.

Discussion

Digital radiography involves advanced computer technology that has made significant impact in dentistry. Because of the growing popularity of this technology in the clinic, incorporation of digital radiography instruction in the classroom has become even more popular and pervasive. Advanced digital radiographic techniques and instruments have become an integral part in the design of radiology courses throughout different dental disciplines [2,7,8,10,14,16,30]. The purpose of digital radiography is the same as with film-based radiography, namely to produce diagnostic images of the oral structures for assessment of dental conditions. The purpose of this study was to determine if the instruction of digital radiography at one dental school was beneficial to future clinical practice. A survey was conducted to assess the perception of dental school alumni to the various digital radiographic modalities used in their respective practices and to determine if they could reflect on their radiology educational training thereby trying to establish a correlation.

With reference to questions pertaining to the knowledge of principles in digital radiography, participants received in their respective programs (DDS or DH), there was overall consensus that alumni obtained high level of training and technical knowledge to be prepared to handle various digital systems in private practice [2,26]. Respondents were also assertive of the intellectual capacity, knowledge and experience of radiology faculty to teach various digital radiography techniques. Successfully implementing teaching innovation and incorporating new technologies with hands on experiences is a chief way to help increase student learning. Alumni were able to implement digital radiography while better understanding different details of applying the technology.

Under the category on handling of sensors in the survey, it was obvious that alumni who use PSP (25.1%) had a clear idea about its proper handling and were able to confirm their superiority over film. They also displayed knowledge of how the PSP plates should be disinfected/cleaned [1]. This reiterates the view that the respondents have carried the didactic, pre-clinical and clinical knowledge obtained in digital radiography during their dental training into prudent private practice scenarios. Survey respondents were aware of the possible damage that can occur to PSP plates during handling.

Digital radiographic systems are now available for extra-oral imaging also. Extra-oral imaging is an imaging modality where the "source of x-ray photons" and detector (film/sensor) are situated outside the patient's head. The digital radiographic systems can be classified into Direct, Semi-Direct and Indirect Systems. Direct systems include Charged-Couple Devices (CCD) and Complementary Metal Oxide Semi-conductors (CMOS). Semi-Direct systems include PSP and indirect systems scan the x-ray film using a flat-bed scanner. Though an image could be obtained using film or digital methods, the technique (projection geometry etc.) for for performing the x-ray procedure on a patient remain the same. However, the radiation dose between film and digital systems is different. An advantage of digital systems if the use of lower radiation than film; the degree of reduction varies with the particular system used. It has been brought to light from the findings of this study that alumni are using CCD digital radiographic systems in practice even though that particular system is not being taught or used in the dental school radiology facility [2,4,7,14]. It is clear that future curricula in digital radiography should be geared towards demonstrating CCD systems to students [16]. Graduates strongly believe that digital radiography will improve diagnosis compared to film radiography contrary to what was taught at dental school, even though there is no convincing evidence to substantiate this view, including from this study [13,17,18,25,27].

It is imperative from the results of the survey that teaching digital radiography to dental students is vital for the graduating dental professional's radiological needs in practice. This signifies the need for radiology faculty to be adequately trained and exceedingly knowledgeable to impart concepts, principles, techniques and applications of digital radiography in dentistry. Results from this survey clearly establish that radiology faculty who taught digital radiography at this dental school during the years surveyed served as a beacon of information in transmitting vital knowledge in this area to future dentists [2,16,31,32].

Limitations of the Study

The sample may not have been representative of the population from which it was taken due to the voluntary nature of responses solicited (47.4% response rate). The reasons for this response rate were considered to be the following: (i) Survey was sent to the graduates/alumni through email. Some surveys could have gone to the spam folder and is possible that recipients never viewed it. Some graduates might have changed their personal email (ii) Time constraints - busy schedule of graduates could be considered to be a deterrent for non-response. It is possible that alumni who did not respond were those that did not receive the mail-in survey or did not favor the implementation of digital radiography. Data was only obtained from alumni since the implementation of the digital technology at the dental school.

Recommendations for Future Research

This study serves as a great baseline for the importance of efficient faculty calibration for effective instruction. However, follow-up studies should be conducted that include more programs across more than one dental and/or medical school that uses this type of equipment. A multi-institutional study involving various radiology departments to assess satisfaction rates among graduates/alumni would give great insight for making improvements in teaching digital radiography. In addition, this study did not show the instructional faculty's perceptions of the new technology. Therefore, follow-up studies should focus on how both faculty and alumni feel incorporating this into the teaching and learning pedagogy will improve student learning.

There is convincing evidence in the literature that foundation knowledge of digital radiography is essential for viewing and interpreting digital images [33-37]. This particular study set out to investigate, through a well-calibrated survey, if that knowledge had been adequately imparted at a dental institution. There is perceived awareness that digital radiography also increases the number of retakes due to the ease with which digital radiographs are made [38,39]. Questions pertaining to radiographic retakes were also included in the present survey.

Conclusions

Digital radiography is one of the most widely utilized tools for diagnosis and treatment planning in dentistry. Therefore, students who can acquire a wide learning experience of the evolving radiology technologies with hands-on training will have a much better learning experience. The results of this survey study render satisfactory opinion about the status of educational training in dental digital radiography obtained by alumni at one dental school (University of Detroit Mercy School of Dentistry) and suggests minor changes to the radiology curriculum such as including demonstration of CCD systems that are emerging as the most commonly used digital radiographic system used in clinical dental practice today. In addition, this study serves as an excellent foundation for efficient faculty calibration in radiology for effective pedagogy.

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