

Special Edition
"Radiographic Interpretation as a
Teaching Tool for Dental and
Dental Hygiene Students"

Research

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A Comparison of Radiographic Retakes between Junior and Senior Dental Students

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ABSTRACT

Objective: The objective of this retrospective, records-based study was to compare radiographic retakes between junior year (DS3) and senior year (DS4) dental students at a research non-intensive dental school to provide students with research opportunities.

Methods: Data was collected from 260 de-identified radiographic evaluation forms of full mouth series (FMS) radiographs completed by DS3 students, and 260 similar forms completed by DS4 students. Information collected included criteria for evaluation of individual radiographic images and the number of retakes required based on specific criteria. Data was analyzed using 2×2 contingency tables with Fischer's exact test and two-tailed *p* values with significance at *p*<0.05.

Results: For DS3 students 75.2% of evaluated radiographs were categorized as having no technical errors with all criteria met. For DS4 students 76.4% of evaluated radiographs were free of technical errors with all criteria met. Under these conditions it was determined by radiology faculty that no retakes were necessary. For DS3 students 12.8% of exposures analyzed were categorized as necessitating a retake. For DS4 students 10.9% of the exposures analyzed were categorized as a retake. This represented a decrease in overall retake error from the DS3 to the DS4 year and is significant (*p*=0.0050). The most common radiographic projection that led to a retake for DS3 students was the mandibular left molar periapical projection. The most common radiographic projection that led to a retake radiograph for DS4 students was the maxillary right molar periapical projection.

Conclusions: Student researchers were provided an opportunity to conduct clinically relevant research. Data showed that there were significantly more acceptable radiographic projections accomplished by DS4 students as compared to DS3 students. There was a significant reduction in the supplemental retake rate by DS4 students compared to DS3 students, and a significant reduction in overall retake rate by DS4 students.

KEY WORDS: Radiographs; Radiology education; Retake rate; Student research.

ABBREVIATIONS: FMS: Full Mouth Series; DS3: Junior year; DS4: Senior year; PA: Periapical.

INTRODUCTION

Pre-clinical training in radiology at a dental school is intended to prepare students for radiology procedures both in clinic and in future private practice. Pre-clinical hands-on training in intra-oral radiographic projections should be accomplished early in a student's curriculum to prepare them for clinical practice.¹ To this end, dental students attending Detroit Mercy Dental, begin radiology training during the first semester of the sophomore year. The optimal way to learn specific radiographic procedures is precisely as it will be tested² pre-clinical manikin laboratory sessions on technique are conducted contemporaneously with didactic teaching on the fundamentals of the physics of radiation. Laboratory demonstration sessions are followed by pre-clinical competency exams on selected radiographic projections to be performed on manikins.

It has been found that acquired skills can be long-lasting if repeated practice and feedback are given.³⁻⁵ Therefore in the junior year (DS3) of the dental curriculum students apply cognitive skills in image-making to produce diagnostically acceptable radiographic images on patients. Transition from pre-clinical radiology lab courses to clinical radiology can pose significant challenges to DS3 and fourth year (DS4) dental students. A radiographic evaluation form used in the radiology clinic consists of defined criteria intended as a self-evaluation tool for students to assess radiographic projections. Student evaluation is later verified by calibrated radiology faculty. In several studies peer assessments have been found to be typically inflated and may not correlate strongly with faculty assessments.^{6,7} The form indicates clear policies on the evaluation of radiographic images using a standard set of well-defined and vetted criteria. Evaluations are designed so that retakes are correctly identified, and retake radiographic orders are correctly justified. Retakes, images that must be redone due to error or poor image quality, utilize personnel and other resources unnecessarily and expose patients to excessive ionizing radiation.^{8,9} This is important because faculty and students follow the ALARA principle (as low as reasonably achievable).

Radiographic retake error rates have been reported in several published works. In a similar study to the present one, data from digital mammographs were collected over one year period to evaluate retakes and the reasons for them.¹⁰ Seven percent of the images were marked as retakes. When evaluating causes of retakes, the primary reason was incorrect positioning. Other studies have reported that most film-screen retakes were primarily due to exposure and processing issues, while most digital retakes were due to incorrect positioning.¹¹⁻¹³

Although, research is not formally incorporated into the dental curriculum^{14,15} students at Detroit Mercy Dental having the opportunity to participate in a faculty-mentored research study as participants in the Student Research Program. Therefore, one objective of this study was to provide two dental student researchers with a radiographic assessment of the evaluation of errors that had direct educational and clinical relevance under the supervision of a board-certified radiologist. The second objective of the work was to compare radiographic retakes between DS3 and DS4 dental students at Detroit Mercy Dental. The null hypothesis is that there is no difference in radiographic retakes between DS3 and DS4 dental students.

MATERIALS AND METHODS

This retrospective records-based study was granted expedited IRB approval prior to initiating data collection (IRB Protocol #1516-03). Data was collected from 260 radiographic evaluation forms of full mouth series (FMS) radiographs completed by DS3 students, and 260 similar forms completed by DS4 students. All radiographic projections were graded per criteria stipulated by the radiology department and made available to the student. The forms were collected from one academic year. Evaluation forms

which were not graded, approved and/or counter-signed by authorized Dental Faculty in the Radiology Department were not included in the study. Patient identifiers were removed from the evaluation forms. Faculty identifiers including name and identification number, and all student identifiers and grading scores were also removed from the forms before the student researchers began data collection.

Table 1 summarizes the criteria for evaluation of the FMS consisting of 15 periapical (PA) and 4 bite wing radiographs. Individual radiographic projections were characterized using one of four criteria. For criteria one, the radiograph demonstrates no technical errors, all defined criteria are met, and a retake is not necessary. On the evaluation form this is indicated as a check mark. For criteria two, the radiograph has one or more technical errors but defined criteria are met on the film itself or elsewhere on a different projection, so therefore no retake is necessary. On the evaluation form this is indicated by a question mark. For criteria three, the radiograph contains a technical error resulting in a failure to meet criteria and therefore a retake is required. On the evaluation form this is indicated by "X." For criteria four, the radiograph has no technical error but criteria are not met due to pathologic or anatomic issues and therefore a retake is required. This is indicated on the evaluation form by "S."

Data identifying the specific error type was also recorded from the evaluation forms. In addition, information regarding criteria for evaluation of individual radiographic images of FMS was acquired. All data points were entered into Excel spread sheets for numerical categorical data. Data was then statistically analyzed using 2×2 contingency tables with Fischer's exact test and two-tailed *p* values with significance at *p*<0.05.

RESULTS

A total of 9880 data points on de-identified radiographic evaluation forms were recorded and compared between DS3 (4940 data points) and DS4 (4940 data points) dental students. Data included two categories necessitating a retake (indicated as "X" or "S" as described in Materials and Methods) and two categories for which retakes were not required (indicated as a check mark or question mark as described in Materials and Methods). For DS3 students 75.2% (3715/4940) of evaluated radiographs were categorized as having no technical errors with all criteria met. In comparison, for DS4 students 76.4% (3774/4940) of evaluated radiographs were free of technical errors with all criteria met. It was determined by radiology faculty that no retakes were necessary. The difference in number of technical error-free radiographs between DS3 and DS4 students was not significant (*p*=0.1731).

Radiographs could also be evaluated and categorized as having one or more technical errors, but criteria were met on the film itself or elsewhere on a different projection. Radiology faculty would determine that no retake was necessary

Table 1: Criteria for Evaluation of Individual Radiographic Images of FMS at Detroit Mercy Dental Radiology Clinic.

Radiographic Projection	Description
Maxillary Right Molar PA	First, second, third molar with at least 2 mm of bone around the lamina dura and maxillary tuberosity
Maxillary Right Premolar PA	Distal 1/2 of canine, first, second premolar, first molar, with at least 2 mm of bone around lamina dura
Maxillary Right Canine PA	Canine and distal 1/2 of lateral incisor with at least 2 mm of bone around lamina dura
Maxillary Central-lateral PA	Central and lateral incisors on side being radiographed, with at least 2 mm of bone around lamina dura
Maxillary Central-lateral PA	Central and lateral incisors on side being radiographed, with at least 2 mm of bone around lamina dura
Maxillary Left Canine PA	Canine and distal 1/2 of lateral incisor with at least 2 mm of bone around lamina dura
Maxillary Left Premolar PA	Distal 1/2 of canine, first, second premolar, first molar, with at least 2mm of bone around lamina dura
Maxillary Left Molar PA	First, second, third molar with at least 2 mm of bone around lamina dura and maxillary tuberosity
Right Molar Bitewing	First, second, third molar and distal 1/2 of premolar
Right Premolar Bitewing	Distal 1/2 of canine, first, second premolars and first molar
Left Premolar Bitewing	Distal 1/2 of canine, first, second premolars and first molar
Left Molar Bitewing	Distal 1/2 of second premolar, first, second, and third molar
Mandibular Right Molar PA	First, second, third molars with at least 2 mm of bone around lamina dura
Mandibular Right Premolar PA	Distal 1/2 of canine, first, second premolar and first molar with at least 2 mm of bone around the lamina dura
Mandibular Right Canine-Lateral PA	Canine and lateral incisor with at least 2 mm of bone around lamina dura
Mandibular Central Incisor PA	All four incisors, with at least 2 mm of bone around lamina dura
Mandibular Left Canine-Lateral PA	Canine and lateral incisor with at least 2 mm of bone around lamina dura
Mandibular Left Premolar PA	Distal 1/2 of canine, first, second premolar and first molar with at least 2 mm of bone around the lamina dura
Mandibular Left Molar PA	First, second, third molars with at least 2 mm of bone around lamina dura

for radiographs falling under this category. For DS3 students 12.0% (595/4940) and for DS4 students 12.7% (627/4940) of radiographs were evaluated in this manner. This was not a significant difference ($p=0.3435$). Taking both criteria resulting in no retake necessary together, for DS3 students 87.2% films (4310/4940) were considered acceptable. For DS4 students 89.1% (4401/4940) of the films were considered acceptable. Although statistical analysis of the two individual criteria not requiring a retake were not significant, analysis of the data taken together was significant ($p=0.0002$).

Certain retakes were required as a result of technique or processing error. For DS3 students 7.1% (350/4940) of evaluated radiographs demonstrated a technical error that caused a failure to meet criteria. A retake was required for such radio-

graphs. For DS4 students 6.5% (325/4940) of evaluated radiographs demonstrated a technical error necessitating a retake. The number of retakes due to technical errors for DS3 students compared to DS4 students was not significant ($p=0.3386$). Table 2 summarizes and compares the various reasons for DS3 and DS4 students' retakes due to technical errors. The most common technical error for both DS3 (71.1%) and DS4 (71.4%) students was film placement. The least common technical errors for both groups was having the sensor reversed or upside down, motion blur, parallelism, and double exposure.

Retakes were also a result of supplemental radiographs with criteria not met due to anatomy that required the radiograph be retaken with the same technique or an advanced imaging modality. For DS3 students 5.7% (280/4940) of evaluated ra-

Table 2: Comparison of DS3 and DS4 Retakes due to Technical Errors.

Error Type	#DS3 ^a	%DS3	#DS4 ^b	%DS4
Film placement	249	71.1	232	71.4
Cone cut (central ray error)	29	8.3	27	8.3
Sensor reversed	1	0.3	0	0.0
Vertical angulation	26	7.4	29	8.9
Horizontal angulation	20	5.7	12	3.7
Motion blur	2	0.6	1	0.3
Parallelism	0	0.0	0	0
Double exposure	0	0.0	0	0
Sensor upside down	0	0.0	1	0.3
Vertical bitewing	23	6.6	17	5.2

^aNumber of errors per 350 data points for DS3 class

^bNumber of errors per 325 data points for DS4 class

diographs did not show a technical error, but criteria were not met due to pathologic or anatomic problems and a retake was required. For DS4 student 4.3% (214/4940) of radiographs necessitated a retake due to this evaluation. This is a significant reduction in supplemental radiograph retakes comparing DS3 to DS4 students ($p=0.0027$).

Taking both technical errors and supplemental retakes together, for DS3 students 12.8% (630/4940) of films analyzed were categorized as a retake. For DS4 students 10.9% (539/4940) of the films analyzed were categorized as a retake. This is a decrease in overall retake error from the DS3 to the DS4 year and is significant ($p=0.0050$).

The most common radiographic projection that led to a retake for DS3 students was the mandibular left molar periapical projection (79/630, 12.5%). The least common projection that led to a retake was the mandibular central incisor periapical projection (5/630, 0.8%). The most common radiographic projection that led to a retake radiograph for DS4 students was the maxillary right molar periapical projection (72/539, 13.4%). The least common projection that led to a retake for DS4 students was the mandibular right canine-lateral periapical projection (7/539, 1.3%).

Based on radiographic evaluation form data, for DS3 students 21.9% (57/260) of FMS were clinically acceptable and

did not require any retakes. Using similar criteria, for DS4 students 26.9% (70/260) of FMS were clinically acceptable and did not require any retakes. This represents an increase of 5% in production of retake-free FMS between DS3 and DS4 students however this is not significant ($p=0.2205$) (Table 3).

DISCUSSION

Detroit Mercy Dental is a research non-intensive institution, but has a robust Student Research Program fully supported by the administration. Faculty members serve as mentors and provide guidance in all stages of the research method. This study demonstrates the potential of student researchers to contribute to scholarly activity in a meaningful way^{16,17} and it accomplished the objective to provide two dental student researchers with a study that had direct educational and clinical relevance.

To address the second objective of this study, under the mentorship of a board certified radiologist, the student researchers gathered data from radiology evaluation forms to analyze retakes and to compare retakes between a cohort of DS3 and DS4. Data analyses showed that there were significantly more acceptable projections accomplished by DS4 students compared to DS3 students. There was a significant reduction in the supplemental retake rate by DS4 students compared to DS3 students, and additionally a significant reduction in the overall retake rate by DS4 students. In a study comparing re-exposure data

Table 3: Number and Percentages of Errors in Criteria for Evaluation of Individual Radiographic Images of FMS at Detroit Mercy Dental Radiology Clinic.

Radiographic Projection	#DS3 ^a	%DS3	#DS4 ^b	%DS4	DS3-DS4 ^c
Maxillary Right Molar PA	68	10.8	72	13.4	-3
Maxillary Right Premolar PA	29	4.6	15	2.8	+14
Maxillary Right Canine PA	17	2.7	12	2.2	+5
Maxillary Central-lateral PA	41	6.5	33	6.1	+8
Maxillary Central-lateral PA	27	4.3	30	5.6	-3
Maxillary Left Canine PA	15	2.4	19	3.5	-4
Maxillary Left Premolar PA	19	3.0	21	3.9	-2
Maxillary Left Molar PA	56	8.9	50	9.3	+7
Right Molar Bitewing	29	4.6	26	4.8	+3
Right Premolar Bitewing	29	4.6	22	4.1	+8
Left Premolar Bitewing	26	4.1	27	5.0	-1
Left Molar Bitewing	29	4.6	24	4.5	+5
Mandibular Right Molar PA	78	12.4	63	11.7	+15
Mandibular Right Premolar PA	27	4.3	18	3.3	+9
Mandibular Right Canine-Lateral PA	16	2.5	7	1.3	+9
Mandibular Central Incisor PA	5	0.8	11	2.0	-6
Mandibular Left Canine-Lateral PA	17	2.7	14	2.6	+3
Mandibular Left Premolar PA	23	3.7	12	2.2	+11
Mandibular Left Molar PA	79	12.5	63	11.7	+13

^aNumber of errors per 630 data points for DS3 class

^bNumber of errors per 539 data points for DS4 class

^cChange from DS3 to DS4, a negative number indicates an increase in retakes, and a positive number indicates a decrease in retakes

of dental students in an oral and maxillofacial radiology clinic, it was reported that the re-exposure rates improved as the year progressed.¹⁸ Results of the current study suggest that dental students retain their cognitive skills in radiographic image-making learned during the pre-clinical lab courses and assessed by competency evaluations. This student-led research study provided valuable data to the radiology faculty for assessment of the radiology curriculum.

In a comparison of film-retake rates and causes in digital radiography compared to conventional methods, the most common reasons for retakes in conventional radiography was underexposure, overexposure, and positioning errors.¹⁹ The most common reason for retakes in digital radiography was positioning errors. Incorrect positioning was determined to be the main reason for retakes in several other studies.¹⁰⁻¹³ In the current study the main reason for retakes for both DS3 and DS4 students was technical errors in film placement.

CONCLUSION

The objective of study was to compare radiographic retakes between DS3 and DS4 dental students at a research non-intensive dental school to provide students with research opportunities. There were significantly more acceptable radiographic projections accomplished by DS4 students compared to DS3 students. There was a significant reduction in the supplemental retake rate by DS4 students compared to DS3 students, and additionally a significant reduction in the overall retake rate by DS4 students. The main reason for retakes for both DS3 and DS4 students was technical errors in film placement.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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