Comparison of direct digital and conventional radiography for the detection of proximal surface caries in the mixed dentition

Kristen K. Uprichard, DMD   Brad J. Potter, DDS, MS   Carl M. Russell, DMD, PhD   Tara E. Schafer, DMD, MS
Steven Adair, DDS, MS   R. Norman Weller, DDS, MS

Dr. Uprichard was a pediatric dentistry resident at the time of the study, and is currently in private practice, Greenville, South Carolina; Dr. Potter is an associate professor, Department of Oral Diagnosis and Patient Services; Dr. Russell is a biostatistician, Department of Biostatistics and Research Affairs; Dr. Schafer is an assistant professor, Department of Pediatric Dentistry; Dr. Adair is a professor and chair, Department of Pediatric Dentistry; and Dr. Weller is an associate professor and chair, Department of Endodontics, at the School of Dentistry, Medical College of Georgia, Augusta, Georgia.

Abstract

Purpose: The aim of this study was to compare the performance of direct digital radiography and traditional dental radiography for the detection of proximal surface dental caries in the mixed dentition.

Methods: 15 quadrants of extracted teeth, arranged from the primary canine to permanent first molar, were imaged using direct digital (Schick Technologies, Long Island City, NY, USA) and conventional films (D-speed and E-speed Plus; Eastman Kodak Co., Rochester, NY, USA). Five pediatric dentists viewed the images and scored the 270 proximal surfaces for presence of caries on a 5 point scale and extent of caries on a 4 point scale. The teeth were sectioned and viewed microscopically to determine the gold standard. Receiver operating characteristic (ROC) analysis and analysis of variance (ANOVA) were used to evaluate the viewer's performance for detecting proximal caries using the 3 different image receptor types.

Results: Experienced examiners were significantly more accurate in diagnosis of proximal surface caries using either D-speed or E-speed Plus films than they were using the direct digital receptor. The mean areas under the ROC curve (A_z) for the viewers were 0.7595 for D-speed film, 0.7557 for E-speed Plus film, and 0.5928 for the direct digital receptor. The results also indicated that selected viewers' accuracy increased when viewing the direct digital images a second time.

Conclusion: CCD based direct digital radiography was not as accurate as conventional film images for the purpose of diagnosing proximal surface caries in the mixed dentition. However, the results imply that with increased experience, direct digital images may be as accurate as conventional film based images for diagnosis. (Pediatr Dent 22:9-15, 2000)

Conventional dental radiographs are the primary imaging modality for the diagnosis of proximal caries. However, new imaging technology has become available. Direct digital intraoral radiography has been developed in the last decade[1] and its use is becoming more popular. With the introduction of any new diagnostic tool, research must be performed to evaluate its diagnostic abilities.

Several studies have compared direct digital radiography and conventional radiography with regard to diagnosing proximal surface dental caries. White and Yoon[2] compared the Schick CDR digital charged coupled device (CCD) system (Schick Technologies, Long Island City, NY, USA) to E-speed film for proximal caries detection and found that dentists using digital images and E-speed film performed equally well in interpreting proximal caries. In a similar study, Tyndall et al.[3] also compared direct digital radiography and E-speed films for proximal caries detection. Although significant differences were seen among readers, readings, and radiograph type, no differences in performance were noted between the unenhanced Sidexis images and the E-speed images. Dove and McDavid[4] also compared digital and plain film images. Using receiver operating characteristic (ROC) analysis, nonenhanced digital images were found to be as diagnostically accurate as conventional radiographs. Price and Ergul[5] also used ROC analysis to compare the diagnostic accuracy of film-based and direct digital radiology in proximal caries detection using both natural and artificial lesions. They found film-based radiography to be superior to digital radiography for detection of proximal caries.

An in vivo study by Naitoh et al.[6] used direct digital and conventional film images and evaluated observer agreement in the detection of proximal surface caries. They found that observer agreement was similar with both systems. They concluded that the digital modality was as reliable as conventional radiography for proximal caries diagnosis.

Neilson et al.[7] used conventional radiographs and a digital storage phosphor system to compare the ability to detect cavitation in approximal surfaces of primary teeth. They found no significant difference in the diagnostic accuracy between the two modalities for detection of cavitation.

In a recent extensive review of the literature on digital radiography and caries diagnosis, Wenzel[1] concluded that "digital intraoral radiography appears to be as accurate as current dental films for the detection of caries in general." From the literature cited, this also appears true for proximal carious lesions when evaluated independently. All of the studies to
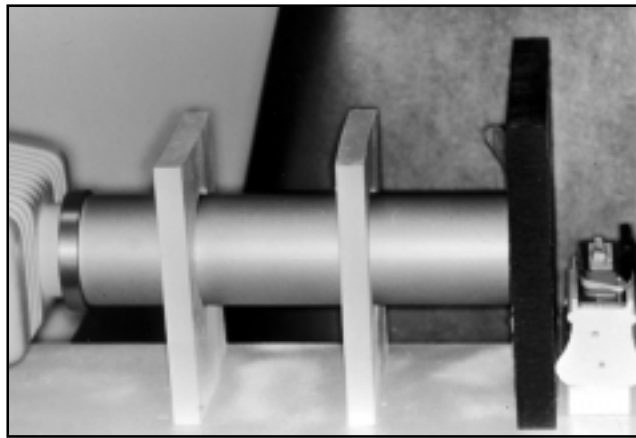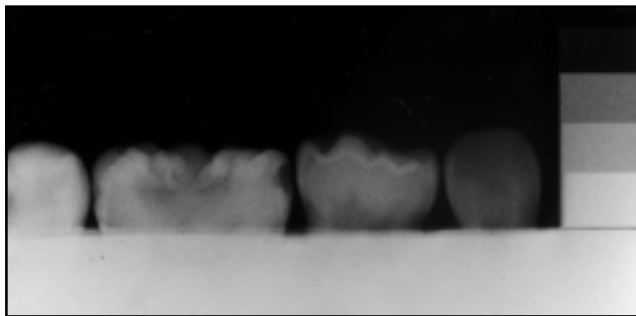
Fig 1. Alignment optical bench device.

Fig 2. Conventional E-speed film image of a quadrant phantom. The image of the aluminum step wedge is seen mesial to the primary canine.

date, except the study by Neilson et al.[7], compared direct digital images and conventional radiographs using only permanent teeth. There have been no studies to date comparing CCD based imaging and conventional imaging techniques for proximal caries detection in the mixed dentition.

The purpose of this study was to compare the performance of direct digital radiography and traditional dental radiography for the detection of proximal surface dental caries in the mixed dentition.

Methods

Specimen sample

Prior to the start of this study, Human Assurance Committee approval was obtained for the use of anatomical specimens. Primary canines, primary first and second molars, and permanent first molars were collected following routine dental extractions unrelated to this study. The specimens were then sorted to produce 16 quadrants of teeth, arranged from the primary canine to the permanent first molar. The sorting procedure involved visual inspection of the proximal surfaces in order to provide a random mix of caries free teeth and those with proximal carious lesions, ranging from incipient decalcification to frank cavitation. Each quadrant was then mounted in dental stone, closely approximating normal anatomic positions, and each phantom was identified with a unique number for future reference.

Image acquisition

Three quadrant setups were selected randomly and radiographed five times using a standardized technique for verification of a clinically acceptable range of film density and contrast. This preliminary protocol used a 4-step aluminum step wedge positioned at the mesial aspect of the primary canine, and an alignment optical bench device (constructed on site) with a 25 mm acrylic soft tissue filter positioned between the beam indicating device and the anatomical phantom (Fig 1). The optical bench was constructed to provide consistent and ideal alignment between the x-ray beam, object, and film. The preliminary radiographs were acquired at 65 kVp, 15 mA, with a source-to-film distance of 41 cm and an object-to-film distance of 2 cm using a GE 1000 Dental X-ray Unit (General Electric Company, Milwaukee, WI, USA). The radiographs were acquired on size 2 Ultraspeed film (Eastman Kodak Co., Rochester, NY, USA) and size 2 Ektaspeed Plus film (Eastman Kodak Co., Rochester, NY, USA). The D-speed films were acquired at exposure settings of 0.6, 0.8, 1.0, 1.25, and 1.5 seconds, and the E-speed films were exposed at 0.4, 0.5, 0.6, 0.8, and 1.0 seconds. All films were processed in an Dent-X 9000 automatic processor (Dent-X, Elmsford, NY, USA) equipped with automatic replenishing, using fresh Kodak RP X-OMAT developer and fixer (Eastman Kodak Co., Rochester, NY, USA).

Optical densities were then recorded using a densitometer X-Rite Model 301 (X Rite, Inc., Grandville, MI, USA) for each step wedge image and a comparative analysis was completed to verify calibration of image acquisition techniques and processing procedure. Student t-test comparisons of the corresponding optical densities indicated that these techniques were calibrated. The images were then evaluated visually, and an exposure setting was selected that provided the most clinically acceptable film density (0.8 seconds for E-speed and 1.25 seconds for D-speed). All 16 quadrant phantoms were then radiographed using each film type with the established standardized protocol. A total of 32 plain films were acquired (Fig 2).

Digital imaging

All 16 quadrant phantoms were imaged under identical conditions with the CDR direct digital imaging system (Schick Technologies, Long Island City, NY,USA). The manufacturer's size #2 image receptor was used. Three digital images were initially acquired of each quadrant using 65 kVp, 15 mA and 0.3, 0.35, and 0.4 seconds for a total of 48 digital images (Fig 3). Visual assessment of a clinically acceptable density and contrast established the exposure time of 0.35 seconds for the direct digital images. The 16 direct digital images of the

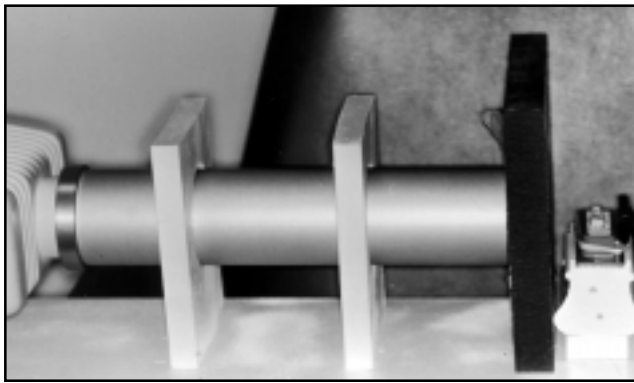| Table 1. Areas under the ROC Curve (A_z) for Each Viewer in the Detection of Proximal Caries			
Viewer	D-speed	E-speed Plus	Digital
1	0.8620	0.8359	0.6414
2	0.7164	0.7745	0.6428
3	0.7528	0.7546	0.5003
4	0.7189	0.7896	0.5516
5	0.7644	0.6505	0.6631
Mean	0.7595	0.7557	0.5928

Fig 3. Direct digital image of the same quadrant phantom seen in Fig 2.

appropriate exposure parameters were then selected for this study. Following all image acquisition, one of the experimental sets was excluded from the study due to excessive overlap of the contacts in the original phantom setup.

Viewer image interpretation

Five pediatric dentists, with a range of time in clinical practice from 2-28 years, were selected to interpret all of the images under standardized viewing conditions. Film viewing occurred on a masked viewbox with dimmed overhead lighting without the aid of any viewing aides (magnification). Digital image viewing occurred in the same room with similar lighting conditions using the CDR monitor and software (Ver. 1.81). Viewers were not allowed to adjust the contrast or density of the images on the monitor. Unlimited time was provided for viewing, but the viewers were instructed not to go back and review a film or image once it had been scored. For each phantom, six surfaces were evaluated: 1-distal of the primary cuspid, 2-mesial and 3-distal of the primary first molar, 4-mesial and 5-distal of the primary second molar, and 6-mesial, of the first permanent molar. The viewers were instructed to score these six surfaces on each film and digital image for the presence and extent of caries. For presence of caries, the viewers scored the surfaces as 1-definitely present, 2-probably present, 3-unsure, 4-probably not present, and 5-definitely not present. For extent, the viewers scored the surfaces as 1-no caries present, 2-caries in enamel only, 3-caries less than or equal to half the way from the external surface of the tooth to the pulp, and 4-caries greater than half the way from the external surface of the tooth to the pulp. There was a minimum of a two-week period of time between the film viewing and the digital image viewing for each of the viewers in order to minimize image recognition. Three of the five viewers were selected at random to view some or all of the images a second time in order to evaluate intra-examiner reliability. One of the three viewed all images a second time, one viewer viewed only the film images a second time, and the third viewer viewed only the digital images a second time.

Gold standard

At the completion of all image acquisition and viewing, the teeth were separated from the phantoms and individually embedded in a clear orthodontic resin (Caulk, Milford, DE, USA) in preparation for sectioning. As a precaution, a round orthodontic wire was embedded along the mesial side of each tooth so that once sectioned, there would be no errors in surface iden-

tification. Each tooth was sectioned mesio-distally along the central groove using an Isomet 2000 precision saw (Buehler, Lake Bluff, IL, USA) with a 0.55mm blade, 200 pounds of pressure, and 2,500 rpm.

Following sectioning, the teeth were examined independently by two evaluators using a light microscope at 10X power and increased to 40X power if necessary. Any discrepancies in section scoring were then reviewed jointly and a final consensus evaluation was determined for each surface of each specimen.

Data analysis

Receiver operating characteristic (ROC) analysis[8] was used to evaluate the viewer's performance for detecting caries using the three different image receptor types (D-speed film, E-speed Plus film, and the direct digital receptor). ROC curves were produced (ROCKIT, Apple Macintosh version, Charles E. Metz, The University of Chicago, Chicago, IL, USA) for image receptor type, viewer, extent of caries, and repeat viewing of the images. In this analysis, the curves are produced using a maximum-likelihood curve fit of the true positive fractions versus the false positive fractions. The area under such a curve (A_z) serves as an index of diagnostic accuracy and ranges from perfect accuracy ($A_z=1$) to pure chance ($A_z=0.50$). Evaluation of differences in area under the curves for this study was completed using a univariate Z-score test[9] and analysis of variance (ANOVA; SAS Statistical Software, Ver. 6, SAS Institute, Cary, NC, USA) together with the least squares mean test. The level of significance was established at $P=0.05$.

In order to more closely examine the performance of the viewers and their use of different receptors, the data were stratified by the four levels of histologic extent of caries. In this analysis, the difference between the viewer's value and the
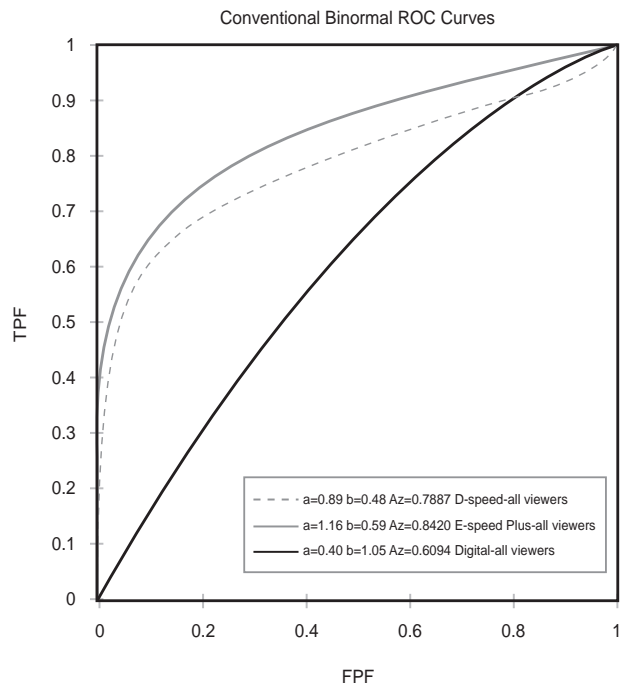

Fig 4. ROC curves and A values of all viewers for the detection of proximal caries using D-speed, E-speed Plus, and direct digital receptors.
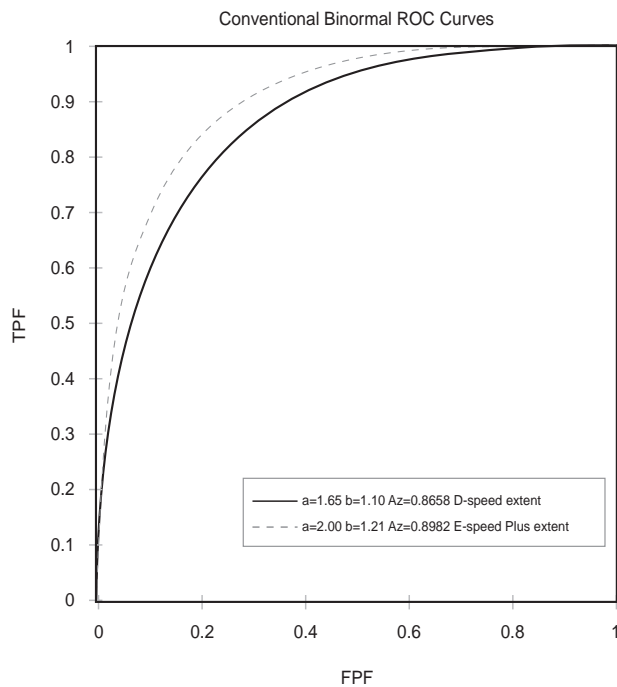
Conventional Binormal ROC Curves

a=1.65 b=1.10 Az=0.8658 D-speed extent
a=2.00 b=1.21 Az=0.8982 E-speed Plus extent

Fig 5. ROC curves and A values of all viewers for the extent of proximal caries using D-speed and E-speed Plus conventional radiographic film.

Conventional Binormal ROC Curves

a=1.97 b=1.19 Az=0.8965 E-speed Plus-extent
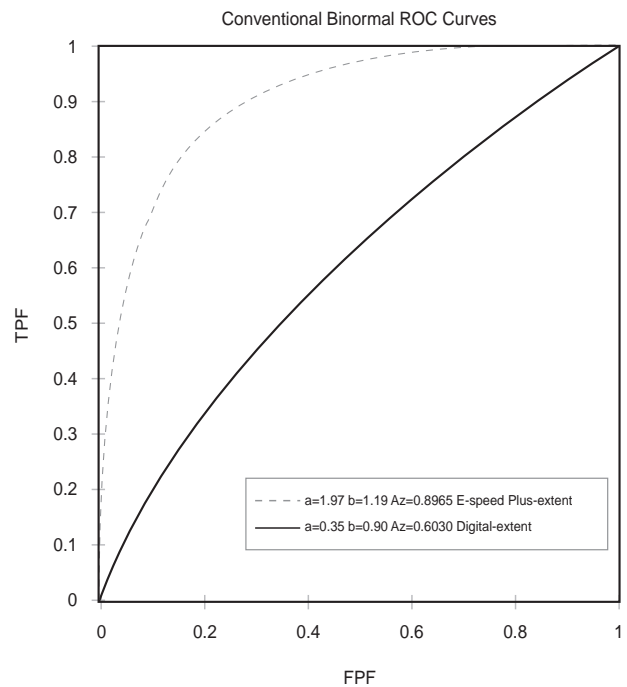a=0.35 b=0.90 Az=0.6030 Digital-extent

Fig 6. ROC curves and A values of all viewers for the extent of proximal caries using E-speed Plus conventional radiographic film and a direct digital image receptor.

histologic value was the response variable of interest. This variable represents the radiographic error in determining the histologic diagnosis. Analysis of variance was performed, which included the effects of: specimen (tooth surface), viewer, receptor, and viewer-receptor interaction.

Results

Each viewer's accuracy for proximal caries detection, expressed as the area under the ROC curve (A_z), is shown in Table 1. The ROC areas ranged from 0.7164 to 0.8620 for D-speed film, 0.6505 to 0.8359 for E-speed Plus film, and 0.5003 to .6631 for the direct digital receptor. Analysis of variance (ANOVA) found no significant differences between viewer's (P=0.3056), but did find a significance difference among receptor types (P=0.004). Least square means adjusted for viewers showed no significant differences between D-speed and E-speed Plus types (P=0.96). However, a significant difference was noted between the intraoral films and the direct digital receptor (D-speed P=0.0031; E-speed Plus P=0.0034).

The pooled scores from the five viewers were used to produce an ROC curve for the three imaging receptors (Fig 4). Using the pooled data, it can be seen that both intraoral film types outperformed the digital imaging, and that E-speed

Plus film actually outperformed D-speed film. Likewise, from the pooled data, there was no significant difference between D-speed and E-speed Plus film (P=0.3077), while a significant difference was found between D-speed film and the digital receptor (P=0.0008) and between E-speed Plus film and the digital receptor (P=0.0001).

ROC curves were produced for the viewers' ability to judge the extent of caries penetration in the proximal surfaces of the teeth (Figs 5, 6, and 7). The viewers' ability was slightly higher for E-speed Plus film than it was for D-speed film, but there was no significant difference (univariate Z-score from ROCKIT; P=0.3445). However, both film receptors were significantly better at demonstrating caries extent over the digital receptor (univariate Z-score from ROCKIT; D-speed/digital P=0.0001, E-speed Plus/digital P=0.0001).

In order to evaluate intraviewer reliability, one of the readers viewed the images for all of the receptors twice, one of the readers viewed just the two film based receptors twice, and a third reader viewed only the digital receptor images twice. ROC curves were generated for all of the combinations. The areas under the ROC curves are shown in Table 2. Viewer 3 improved in each receptor type between the first and second reading. While there was no significant difference in the two

Table 2. Areas under the ROC Curves (A_z) for the First and Second Viewing of the Various Image Receptor Types					
Viewer	D-speed-1st view	D-speed-2nd view	E-speed P-1st view	E-speed P-2nd view	Digital-1st view	Digital-2nd view
3	0.7528	0.9224	0.7546	0.9139	0.5003	0.8501
4	0.7189	0.7345	0.7896	0.7530		
5					0.6631	0.7270

Table 3. Percentage of Responses and Results of ANOVA Stratified by Histologic Level															
	Hist Level=1 (N=39)				Hist. Level=2 (N=18)				Hist. Level=3 (N=15)				Hist. Level=4 (N=18)			
Viewer/Image Type	1·	2	3	4	1	2·	3	4	1	2	3·	4	1	2	3	4·
Viewer 1																
C··	75	15	5	5	50	45	5	0	33	40	20	7	11	0	17	72
D	84	8	8	0	72	28	0	0	40	46	7	7	5	5	23	67
E	92	8	0	0	67	28	0	5	40	40	13	7	5	5	23	67
Viewer 2																
C	94	3	3	0	78	17	5	0	47	20	27	6	6	6	16	72
D	95	0	5	0	67	28	5	0	47	20	27	6	6	6	27	61
E	94	3	3	0	83	11	6	0	47	20	27	6	11	0	22	67
Viewer 3																
C	89	5	3	3	61	33	0	6	53	27	13	7	11	0	50	39
D	79	6	5	0	56	39	6	0	27	47	20	7	6	6	16	72
E	74	18	3	5	50	44	6	0	20	47	27	6	0	11	17	72
Viewer 4																
C	90	0	3	7	72	17	0	11	46	7	40	7	6	6	0	88
D	87	0	8	5	67	11	11	11	33	0	47	20	16	6	6	72
E	91	3	3	3	67	11	11	11	40	7	40	13	6	6	0	88
Viewer 5																
C	87	13	0	0	56	39	6	0	46	40	7	7	6	16	39	39
D	97	3	0	0	61	33	6	0	53	33	7	7	6	11	50	33
E	100	0	0	0	72	28	0	0	46	40	7	7	6	11	56	27
Effects in ANOVA (P-values)																
Viewer	0.0002				0.0227				0.0001				0.0001			
Receptor	0.2660				0.9583				0.2968				0.4938			
Viewer-Receptor Interaction	0.0592				0.5210				0.1005				0.0198			

·Indicates the correct histological diagnosis.
·· C=Direct digital receptor, D=D-speed film, E=E-speed Plus film.
Note: Percentages are rounded to preserve equalities and to add to 100% within each viewer/image type.

film based receptors (univariate Z-score from ROCKIT; $P=0.2209$ D-speed, $P=0.2898$ E speed Plus), there was a significant improvement in the second reading of the digital receptor images (univariate Z-score from ROCKIT; $P=0.0025$). Viewer 4's accuracy increased slightly on the second reading of the D-speed films (univariate Z-score from ROCKIT; $P=0.8716$) and decreased slightly on the second reading of the E-speed Plus films (univariate Z-score from ROCKIT; $P=0.6802$). Viewer 5 improved in accuracy on the second reading of the digital images, but there was no significant difference between the readings (univariate Z-score from ROCKIT; $P=0.6294$).

Table 3 summarizes the data and the analysis of variance for each level of histologic extent. For level 1, viewers are most likely to correctly label the histologic extent. For levels 2, 3, and 4, viewers are less likely to label the exact histologic extent. The analysis of variance shows that for level 4, there was a significant viewer-receptor interaction ($P=0.0198$) and for level 1 there was a nearly significant viewer-receptor interaction ($P=0.0592$). This indicates there is a dual contribution (viewer and receptor) to the error in diagnosis at the high and low end of the histologic extent. That is, the viewers behave differently depending on the receptor being used. At levels 2 and 3 of the histologic extent, the viewer-receptor interaction is not significant (level 2 $P=0.5219$; level 3 $P=0.1005$) and also the receptor effect is not significant (level 2 $P=0.9583$; level 3

$P=0.2968$). However, the variability among viewers is significant (level 2 $P=0.0227$; level 3 $P=0.0001$). Thus, at mid-levels, the viewers contribute mainly to the variation in differences from the histologic diagnosis while at the ends, both the viewer and the receptor contribute to the variation.

Discussion

The results of this study demonstrate several findings of clinical importance in the implementation and use of direct digital radiology. The principal finding was that both film types were statistically more accurate in proximal caries detection than the direct digital receptor. This is contrary to several studies that have been completed previously, primarily conducted using all permanent teeth.[2,3,4,6] In a study using primary teeth, Nielsen et al.[7] showed that a storage phosphor digital system was as accurate as E-speed plus film at the detection of cavitation. However, Price and Ergül[5] demonstrated that a CCD based receptor was less accurate in permanent teeth for caries detection than was E-speed film. The majority of these studies have been conducted in a fashion similar to this study.

The second major finding of this study was that digital imaging was significantly less accurate in demonstrating the extent of caries than was either of the film images. In breakdown of the raw data, we discovered that viewers were accurate with digital imaging in reporting that no caries was present when histologically the tooth surface was caries-free. However,
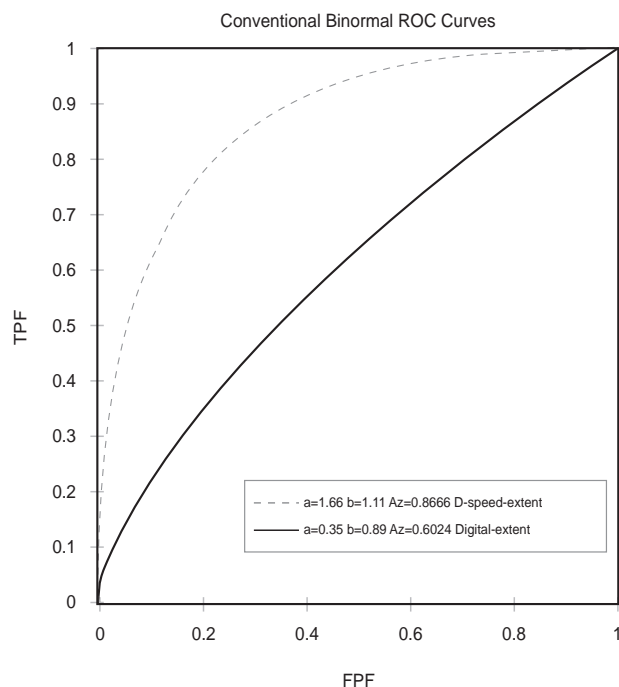
Conventional Binormal ROC Curves

Fig 7. ROC curves and A$_z$ values of all viewers for the extent of proximal caries using D-speed conventional radiographic film and a direct digital image receptor.

the viewers were not as accurate in judging incipient lesions, often indicating that no caries was present when in fact it was. In today's practice environment of more conservative approaches and attempts at remineralization, these findings of inferior accuracy for digital imaging may not be as critical.

Another finding of note is that all of the image receptors used in this study were not considerably accurate in caries diagnosis when compared to the gold standard. This only moderate agreement with the gold standard is not surprising. It is well known that, although used routinely in the diagnosis of proximal surface caries, radiographs compare poorly to histologic identification of caries presence and extent. One reason for this discrepancy is that incipient enamel lesions detected histologically will not always be evident radiographically. Also, caries penetration is usually more advanced histologically than is apparent on bitewing radiographs. Nonetheless, bitewing radiographs are an essential adjunct for early diagnosis of proximal surface caries.[10] Because the enamel and dentin in primary teeth are thinner and the pulps are larger and closer to the outer surface of the tooth, early diagnosis of proximal surface caries is even more critical.

In considering the results of this investigation, several factors should be taken into account. When establishing the gold standard, only carious lesions that initiated at the outer enamel surface corresponding to the proximal contact area were scored as carious. Because of this, several proximal surfaces may have been erroneously scored as carious by the viewers, due to cervical caries or caries initiating on the occlusal surface and involving the dentin adjacent to the proximal surface. This may have affected the results in regard to presence, but as long as the viewers were consistent among the modalities in scoring of these particular lesions, this did not seem to alter the data concerning the differences among the three modalities for

diagnostic ability. Another factor that may have affected the results is the viewers' interpretation of the extent of carious involvement. It is possible that some of the viewers may have been biased in their interpretation based on their clinical experience and willingness to restore such lesions.

While the results of this study would seem to indicate that direct digital imaging is inferior in caries diagnosis, the results are also indicative that a learning curve may be involved for this technology. All viewers participating in this study had little experience in viewing direct digital images for diagnosis of caries. The viewers were asked to diagnose the images without any pre-investigation training sessions. Both of the viewers that repeated interpretations of the digital images improved on the second viewing. In fact, one viewer improved significantly from a level of almost chance guessing to a level equivalent to the film based images. It is reasonable to assume that with increased viewer experience, accuracy in diagnosis is likely to increase using this modality. It is also possible that with viewer experience and enhancement capabilities, direct digital radiography may prove to be superior in comparison to conventional radiography for diagnosis of proximal surface caries. As an added advantage, viewers involved in this study indicated that the digital images were the easiest images to score. Therefore, implementation of digital imaging in a dental practice must occur with the knowledge that some level of learning and familiarization is to be expected.

Although poor at demonstrating incipient changes or showing the true extent of proximal caries, radiographic images, regardless of their origin, are an essential aid in diagnosis. The results of this study indicate that direct digital radiography, while not initially as accurate as conventional films, have potential use in a pediatric practice. This provides the clinician with another option for diagnostic imaging.

Practitioners should compare the advantages and disadvantages of direct digital to those of conventional radiography, and decide if it is appropriate to incorporate this newer technology into their practices. Ultimately, the goal is to obtain the most diagnostic information with the least amount of radiation dose. While there are many advantages of direct digital radiography, such as speed and dose reduction, it may not be possible to use this technology with every pediatric patient. The sensors are rigid and thicker than film and therefore, smaller children may find it difficult to accommodate the image receptor. Regardless, this technology holds great promise for today's modern pediatric dental practice.

Conclusions

1. Viewers with varying degrees of clinical experience performed more accurately with conventional radiographs than with digital imaging when diagnosing proximal surface caries in vitro in the primary and permanent dentition.
2. There were significant differences between conventional radiographs and CCD-based direct digital radiography for the determination of presence or extent of proximal caries.
3. There are indications that with increased experience in use of direct digital radiography, accuracy in proximal caries diagnosis may approach that of conventional film based imaging.

References

1. Wenzel A: Digital radiology and caries diagnosis. Dentomaxillofac Radiol 27:3-11, 1998.
2. White SC, Yoon DC: Comparative performance of digital and conventional images for detecting proximal surface caries. Dentomaxillofac Radiol 26: 32-38, 1997.
3. Tyndall DA, Ludlow JB, Platin E, Nair M: A comparison of Kodak Ektaspeed Plus film and the Siemans Sidexis digital imaging system for caries detection using receiver operating characteristic analysis. Oral Surg Oral Med Oral Pathol 85: 113-118, 1998.
4. Dove SB, McDavid WD: A comparison of conventional intra-oral radiography and computer imaging techniques for the detection of proximal surface dental caries. Dentomaxillofac Radiol 21: 127-34, 1992.
5. Price C, Ergul N: A comparison of a film-based and a direct digital dental radiographic system using a proximal caries model. Dentomaxillofac Radiol 26: 45-52, 1997.
6. Naitoh M, Yuasa H, Yoyama M, Shiozima M, Nakemerra M, Ushida M, Iida H, Hayashi M, Ariji E: Observer agreement in the detection of proximal caries with direct digital intraoral radiography. Oral Surg Oral Med Oral Pathol 85: 107-112, 1998.
7. Nielsen LL, Hoernoe M, Wenzel A: Radiographic detection of cavitation in approximal surfaces of primary teeth using a digital storage phosphor system and conventional film, and the relationship between cavitation and radiographic lesion depth: an in vitro study. International Journal of Paediatric Dentistry 6:167-172, 1996.
8. Metz CE: Basic principles of ROC analysis. Semin Nucl Med 8: 283-298, 1978.
9. Hanley JA, McNeil BJ: A method of comparing the areas under the receiver operating characteristics curves derived from the same cases. Radiology 148: 839-843, 1983.
10. Kidd EAM, Pitts NB: A reappraisal of the value of the bite-wing radiograph in the diagnosis of posterior approximal caries. British Dental Journal 169:195-200, 1990.

ABSTRACT OF THE SCIENTIFIC LITERATURE

MEDICARE GME REIMBURSEMENT FOR HOSPITAL DENTAL RESIDENCY TRAININGS

This article is presented in two parts. The first section is a brief, but very informative, review of the background, functions, and funding sources of hospital-based dental residency programs. A concise description of the complexities of Medicare's Graduate Medical Education (GME) reimbursement policies is included. Also, funding dilemmas facing hospital dentistry program directors are discussed.

The second section presents a survey conducted by the American Association of Hospital Dentists. The purpose was an attempt to quantify the level of understanding of GME funding by program directors in an effort to develop strategies for improving funding to such programs. A twelve question survey was sent to 474 program directors; programs included hospital based General Practice Residencies and residencies in dental specialties, including Pediatric Dentistry. Questions elicited data regarding various demographic, organizational, and financial aspects of each program. A total of 218 (46%) surveys were returned, representing a total of 848 resident positions (15% from pediatric dental programs).

Some of the more significant findings:
- nearly 28% of the program directors did not understand the issue of GME funding.
- 63.8% said they were not aware of existing hospital policies regarding GME funds.
- 78.4% had no idea what amount of Indirect Medical Funding (IME) was credited to their program.
- 41.3% stated GME funding was not passed on to their departments.
- 52% of programs were not credited with bringing in GME funds.

The article continues with a discussion, at length, on the importance of GME funding for dentistry, as well as the need for program directors to understand hospital finances and the amount of GME monies directed to their hospitals. A Table is included detailing the steps utilized to calculate an institution's Direct GME payment.

Comments: This article was extremely instructive, with each paragraph seeming to contain more information than the previous one. This article not only contains succinct information on all aspects of hospital funding, but it also discusses governmental and hospital politics surrounding such funds. For example, although the Balanced Budget Act of 1997 placed a 'cap' on the number of hospital residency positions supported by Direct GME and IME funds, dental residencies are exempt from this cap. It would be recommended that the entire article be read (and re-read) by anyone involved in any aspect of a hospital-based program. As an aside, definitions for many related (and often confusing) acronyms, such as DGME, IME, HCFA, DRG, etc. are included. **RFM**

Address correspondence to: C. Scott Litch, AAPD, slitch@aapd.org
For information on ordering the 1997 Medicare GME data set, contact: Myla Moss, AADS, mossm@aads.jhu.edu
Medicare GME Reimbursement for Hospital Dental Residency Training: Overview and Reporting of Survey Results. Rutkauskas JS, Litch CS, Glavich GM, Hazlewood AI. J Dent Ed 62(11): 929-33, 1999.
10 references