International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 9, September 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.9.2024.80

**ORIGINAL RESEARCH**

# Comparision of efficacy of intraoral periapical Radiograph (IOPA) and radiovisiography (RVG) in detection of initial caries

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Received date: 08 August, 2024 Acceptance date: 12 September, 2024

## ABSTRACTS

**Background:** Radiography is a commonly used imaging modalityin dental setup to aid in diagnosis. Digital radiography usingradiovisiography (RVG) is a direct digital intraoral radiographicimaging system, requiring a substantial reduction of radiationdosage to the patient over other radiographic techniques usingthe film.**Objective:** This study was undertaken with the aim of comparing thesensitivity of RVG system with intraoral periapical radiograph and also to evaluate thediagnostic accuracy of RVG to conventional radiography along with clinical examination in detection of initial caries.**Material and Method:**Two bitewing radiograph were taken both intraperiapical radiograph(IOPA) and Radiovisiograph(RVG) of same patient. The conventional radiograph was then taken using size 2 Carsteem Ultraspeed (D-speed), double pack film (Carsteem Company,Rochester, NY, USA) exposed with Bio-dent-1070-D-x-ray unit (Bio medicareCoperation, DistThane, Maharastara , India) following the posted guidelines (70 kVp, 8Ma, 25 pulses).The digital image was made by exposing the Vatech RVG 1.5 digital sensor. Total 51 patients were included in this study. Clinical and radiographic score of both RVG and IOPA were compared. **Result and Conclusion:** both radiographs Ultraspeed (D-speed) film and VATECH RVG size 2 super CMOS based digital radiographic sensor significantly underestimated the actual clinical extension of the carious lesions. The mean radiographic differences in estimating the carious depth compared to the true depth were 0.29 mm and 0.42 mm for the VATECH RVG and D-speed film respectively.VATECH RVG images were significantly more accurate than D-speed films in estimating of the carious lesions especially in smaller size lesions.The cavitation percentage increased as the lesion depth increased radiographically and clinically.

**Keywords:** dental caries, digital radiography, intraperiapical radiograph, RVG



## INTRODUCTION

Dental caries is a multi-factorial disease and is influenced by factors such as the bacterial composition of the biofilm, tooth factors, salivary flow rate and composition, consumption of dietary sugars, preventive behaviours and exposure to fluoride. The extent of the influence of factors affecting the caries process varies widely; some factors act directly and the effect of others are more remote. Research in this field continues to inform the prevention and management of the disease. The factors considered here are those that influence the prerequisites for caries within the oral cavity.In caries diagnosis radiography plays an important role. In general the use of radiographs increases the number of caries lesions that are detected. Currently, the performance of digital radiographs for caries diagnosis resembles that of analogue film based radiography. In spite of this, many studies have demonstrated the tendency of radiographic diagnosis to underestimate the severity of lesions. Radiation dose influences the detection of caries lesions. For CCD (Charge Coupled Device)-based X-ray detectors the dynamic range in which acceptable radiographs are produced is rather narrow. Phosphor plate systems on the other hand have a very wide dynamic range

Online ISSN: 2250-3137
Print ISSN: 2977-0122
DOI: 10.69605/ijlbpr_13.9.2024.80

The ICRP (International Commission on Radiological Protection) expressed recently concern about the influence of the dynamic range of digital systems on patient dose.The correct estimation of the interproximal caries extension for teeth continues to be a tough clinical task even for experienced clinicians due to the limitations of direct examination and evaluation of the surfaces of these teeth esp interproximal surfaces. Different diagnostic tools are being used to help giving a more accurate and reliable diagnosis. Examples of these diagnostic toolsare: bitewing radiography (conventional and digital radiography), fiber-optic transillumination (FOTI), digital imaging fiber-optic transillumination (DIFOTI ™), in addition to the other newly developed technologies. Since 1895, when x-rays were discovered, the use of radiographs as a diagnostic tool has become an integral part of clinical dentistry. Conventional bitewing radiography has been an indispensable tool in detecting lesions in posterior teeth since the 1920s. Eastman Kodak Company has been the predominant dental film manufacturer worldwide for the last 80 years and has developed several generations of increasingly faster and better films .[1]

D-speed (Kodak Ultra-speed) film has been manufactured since the 1940s. It became the “gold standard” to which all subsequent films and digital technology has been compared. Two generations of the Ektaspeed films were introduced over the last 20 years with a decrease in the radiation exposure by several folds. Kodak stopped manufacturing Ektaspeed films in 2001 after they started marketing the new Insight (F-speed) films in the spring of 2000. These films are faster than previous versions of intra-oral films (60% faster than D-speed films and 20% faster than E-speed films), but their diagnostic quality has been questioned. As a result, D-speed films are still considered the “gold standard” for bitewing radiographic caries diagnosis and many practitioners still use these films in their offices. Since digital radiography was introduced to the market more than two decades ago, more clinicians are replacing conventional radiographs with digital radiography[2] .

Intraoral digital radiography offers several advantages over conventional radiography, as was shown by several studies. These advantages include: low radiation exposure, elimination of film developing, immediate availability of the generated image for evaluation on the computer screen and digital manipulation to enhance viewing. The actual amount of exposure reduction is dependent on a number of factors including film speed, sensor area, collimation, and retakes. The primary disadvantages of the digital systems include the rigidity and thickness of some sensors, decreased resolution, higher initial system cost, unknown sensor lifespan, difficulties in maintaining infection control with the sensor and the cable to prevent cross-contamination[3].

In digital radiography, the image is constructed using pixels or small light sensitive elements. These pixels can be a range of shades of grey depending on the exposure, and are arranged in grids and rows on the sensor[4]. The digital image can be acquired directly, semi-directly or indirectly.Indirect digital radiographic image can be produced by scanning conventional radiographs using a flatbed scanner and a transparency adaptor, or by using a charged coupled device (CCD) camera instead of the flatbed scanner. Direct digital sensors use either a CCD chip, a solid-state detector composed of an array of Xray or light sensitive pixels on a pure silicon chip and the sensor communicates with the computer through an electrical cable, or complementary metal oxide semiconductor active pixel sensor (CMOS-APS). The CMOS-APS is the latest development in solid state direct digital sensor technology which has several advantages including design integration, low power requirements, manufacturability, and low cost [5]. However, CMOS sensors have more fixed pattern noise and a smaller active area for image acquisition [3].

In the semi-direct image systems, a phosphor storage plate (PSP), also referred to as “photo- stimulable phosphor plate”, is used which stores energy after exposure to radiation and emits lightwhen scanned by a laser scanner that stimulates the phosphor plate and stores a record of the number of light photons detected 4. In the 1980s, Trophy Corporation introduced the first CCD based dental digital radiography system to the market. The system was called Radiovisiography (RVG). Since then various companies have introduced many more CCD based systems offering a variety of options.[6]

In 1994, Digora introduced the PSP technology to the dental digital radiography market. More recently Schick Technologies, Inc. introduced the CMOS digital radiographic detectors to be used in the dental profession. With the rapid development in digital technology, digital radiographic systems are more commonly used by dental practitioners. The RVG sensors, as one example (Trophy Radiologie, Croissy Beaubourg, France [now Trophy, a Kodak Company, Rochester, N.Y]) has been developed over the past 25 years until Eastman Kodak Company recently launched their new digital sensor VATECH RVG with true resolution of more than 20 lp/mm and using the new super CMOS technology with Optical fiber.[7-10] Several studies have been conducted to compare the diagnostic efficacy of CCD to, PSP, CMOS, and/or conventional radiographs to detect the proximal carious lesions. Lots of the studies found these systems to perform similarly.However, most of these studies were conducted based on in-vitro testing. One clinical study found that CCD based direct digital radiography was not as accurate as conventional film images (D and E-speed films) for the purpose of diagnosing proximal caries in the mixed dentition[11]. With advances in computer technology, dentists are able to use computer-based software to aid detection

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of interproximal carious lesions. In the early 1980s the idea of using the computer to interpret radiographic films was considered a new development in the field of oral radiology. In 1984 Pittsand others were able to test one of the early computer based image analysis systems applied to automatically examine the presence of the interproximal carious lesion. Although these studies found this system able to produce a consistent reading for the carious lesion, it was found to be less specific than the human observer[12-13]. These systems were then improved to perform as well as human observers to support the decision for restoring interproximal carious lesions and therefore, were potentially useful in diagnosing these lesions[14-17].

However, the programs developed and evaluated in theses studies have not resulted in support systems available for the general dentist [18]. The Logicon Caries Detector (Logicon Advanced Technology, Los Angeles, CA,USA) is FDA approved software that was introduced a few years ago to aid in the diagnosis of interproximal carious lesions in conjunction with digital intraoral radiographic images. Eastman Kodak Company started to include this software with their newly developed RVG sensors as an adjunct to diagnosing interproximal carious lesions.Few studies have been conducted to evaluate the quality of this software; however, most of these studies were conducted in-vitro. Therefore, comparing the performance of this software to human observers to diagnose the interproximal carious lesions using in-situ validation method will help the general clinician in his decision to restore a carious tooth.[5]

Illuminating teeth to determine the presence of demineralization or caries is a novel method to detect and monitor dental caries. The Digital Imaging Fiber-OpticTransillumination (DIFOTI) system (Electro-Optical Sciences, Irvington, NY; USA), has made this technology accessible for dental practitioners. The principle behind transilluminating teeth is that demineralised areas ofenamel or dentin scatter light (in this case a high intensity white light) more than sound areas [19]. DIFOTI technology uses light, a charge-coupled device (CCD) camera, and computer-controlled image acquisition. The advantages of DIFOTI over radiography include: no ionizing radiation, no film, real-time diagnosis, and higher sensitivity in detection of early lesions not apparent to X-ray, as demonstrated in-vitro [20]. A single fiber-optic cable in the patented mouthpiece delivers light to one of the tooth's smooth surfaces. As this light travels through layers of enamel and dentin, it scatters in all directions toward the non-illuminated surfaces. The light is then directed through the mouthpiece to a miniature electronic CCD camera in the hand-piece. The camera digitally images the light emerging from the various surfaces of the teeth. These images are displayed on a computer monitor in real time and stored on the hard drive for easy retrieval. Carious lesions are visualized as darkened shadows due to the difference in light refraction between healthy and demineralized tissues [21]. Only one recent in-vitro study has compared the interproximal caries depth on images taken with Intra Oral camera, and F-speed films to the actual histological depth of the lesion and found that Intra Oral camera was able to detect surface demineralization at an early stage, but is not able to measure the depth of an approximal lesion [22]. Once again, this study compared the different images in-vitro and used the histological depth as the validation method to determine the carious lesion extension.

## MATERIALS & METHODS

Fifty one carious lesions were included in this study. Approval for the project from the local institutional review board (I.R.B.) was obtained. Each patient was asked to sign a consent and HIPAA forms to participate in the study after explaining the scope of the study to him/her. A full medical and dental history was reviewed at the screening visit at department of oral medicine and radiology, college of dental science and hospital, amargadh. The tooth with a carious lesion was cleaned using prophy paste and rubber cup and then carefully cleaned with cotton pellets and dental floss. After drying the tooth with stream of air, the area of each lesion was evaluated from the mesial, distal, buccal , lingual, and occlusal aspects under direct and reflected light using a standard dental mirror and operatory light. The appearance of a white spot or slight brownish/blackish discoloration was considered indicative of presence of initial caries. Findings from the visual examination were recorded on the patient's data form as "present" or "absent".

Two bitewing radiograph were taken both intraperiapical radiograph(IOPA) and Radiovisiograph(RVG) of same patient. The conventional radiograph was then taken using size 2 Carsteem Ultraspeed (D-speed), double pack film (Carsteem Company,Rochester, NY, USA) exposed with Bio-dent-1070-D-x-ray unit (Bio medicareCoperation, DistThane, Maharastara , India) following the posted guidelines (70 kVp, 8Ma, 25 pulses). One film was used for the study while the duplicate was placed in the patient record. The unit utilizes an 8-inch, round cone that was placed in contact with the ring of the RINN XCP film holding system (Dentsply Company, York, PA, USA) which was placed in contact with the patient's cheek during exposure. The digital imagewas made by exposing the Vatech RVG 1.5 digital sensor (super CMOS(Ez) sensor with optical fiber technology, 20 Line Pairs/mm, 171 lp/mm, 45 x 32 x 8 mm outside dimensions; Vatech dental manufacturer Company, Sutton ,SM1, , USA) with the same x-ray unit following the posted guidelines (70 kVp, 7Ma, 10 pulses) using RINN XCP-DS positioner (Dentsply Company, York,PA, USA). All radiographic images and films were exposed by the primary investigator using the same x-ray unit at the department of Oral medicine and Radiology, College of dental science

DOI: 10.69605/ijlbpr_13.9.2024.80

and hospital, Amargadh . The film was considered unacceptable for the study if there was an overlapping of the proximal contacts or if there was any artifact such that accurate interpretation would not be possible. In such cases another film was exposed. For patients with multiple qualified lesions, additional radiographs were exposed only if the first one did not adequately depict all of the lesions. Each conventional film was developed in an automatic roller-type processor (Automatic Exta oral Velopex processor Velopex Corporation,Des Barrets Green Road,Harledson , USA) with self-replenishing solutions) while the digital radiographic images were saved directly to the electronic patient record. The intra-oral clinical examination included visual Intra Oral examinations. These procedures were performed by the primary investigator and the results were recorded.

When selecting the patients to participate in the study, specific inclusion criteria were: Dental caries should have progressed to a point that it must be restored (at or beyond the DEJ).

**Radiographic Scoring**: Each radiographic image was scored by co investigator . A standard fluorescent dental viewing box (8 in. x 10 in.) was used for examining the D-speed films, with all areas peripheral to the radiographic mounts blocked out to minimize the glare. Vatech RVG were measured directly from a 19-inch computer monitor (Dell UltraSharp 1905FP 19-inch Flat Panel LCD TFT monitor with 1280 x 1024 pixels maximum resolution and 24-bit color depth; Dell Inc., Amargadh, Gujrat) with the Vatech RVG image being automatically enhanced and magnified (7x magnification compared to the size 2 D-speed film).

**Clinical Scoring:** The true clinical depth of the carious lesion was measured from the photographic images by the primary investigator. For each case, several photographs were taken, resulting in a series of photographs depicting the carious process at different depths. The images were examined carefully to identify the one that depicted the lesion at its deepest point. The selection of the photographic images was performed. In all of the cases, the same image was selected both times. Therefore, this procedure was considered reliable. Measurements of the lesions were made directly from the same computer monitor (Dell UltraSharp 1905FP 19-inch Flat Panel LCD TFT monitor with 1280 x 1024 pixels maximum resolution and 24-bit color depth; Dell Inc.,Amargadh ,Gujrat) using the same clear plastic millimeter ruler that was used in measuring the radiographic images. In each case, the distance between the centers of the black marking bands of the reference device was measured first, as this distance was known to be equal to 1.0 mm.The final measured value for each lesion was obtained by taking the average of the two measurements. Once the radiographic and clinical scores were obtained for each lesion, analysis of the collected data was accomplished. Based on visual and radiographic examination of the surfaces of these teeth ranged from sound to dentinal lesions.

The observer was asked to score caries depth clinically on a 5 point scale: SOUND, WHITE SPOT WITH DULL SURFACE, WHITE SPOT WITH SMOOTH SURFACE, CAVITY < 0.5MM, CAVITY >0.5MM

**Data analysis**

This type of data can be analysed using the statistical theory for multivariate discrete data. In our case the relation between the gold standard and the observers' judgments is crucial. When this relation is ideal the diagnosis is perfect: i.e. sensitivity and specificity are 1.00. When, for example, for two different exposure settings the relation to the gold standard is the same, both settings have the same diagnostic accuracy, because sensitivity and specificity depend on the relation between gold standard and observers' judgment. For all tests a significance level of $\alpha = 0.05$ is used. Differences were considered statistically significant when $p \leq 0.05$.

**Objective diagnostic performance**

The statistical comparison between the preferred, just acceptable and unacceptable dose settings showed a statistically significant difference in diagnostic accuracy for caries diagnosis between these settings ( 122.53, 45, 0.0001 2 $\chi$ = df = p < ). Overall, the just acceptable exposure times gave a higher diagnostic accuracy than the preferred and unacceptable exposure times. With respect to the diagnostic accuracy for caries diagnosis, radiologists showed a significantly different probability for correct caries detection then the general practitioners do ( 51.17, 9, 0.0001 2 $\chi$ = df = p < ). However, these overall findings should be put in the perspective of the interaction between the exposure setting and the expertise of the observers ( 29.63, 14, 0.0086 2 $\chi$ = df = p = ). This difference appears in three caries-depth categories, namely sound surfaces, enamel caries and dentin caries.

## RESULTS

Out of the 51 lesions, 36% (18/51) of the D-speed and 30% (15/51) of the Vatech RVG radiographic scorings were at the DEJ (0 mm). 33% (17/51) of the lesions in the VATECH RVG radiographic set were scored between 0.1 and 0.5 mm while 40% (20/51) of the lesions in the D-speed radiographic set were scored between 0.1 and 0.5 mm. Lesions in dentin accounted for 70% (36/51) and 64% (33/51) of scores in the Dspeed and Vatech RVG radiograph scoring sets, respectively. Both radiographic sets were plotted against each other (Table 2) to compare between the scores in each set. The results showed that 45% (23/51) of the lesions were given the same categorical

DOI: 10.69605/ijlbpr_13.9.2024.80

score for both radiographic sets. However, 42% (21/51) were given higher scores (deeper caries extension) for VATECH RVG radiographic set compared to the D-speed set. The remaining 13%(7/51) were scored deeper in the D-speed radiographic set. The difference in scores between the VATECH RVG and D-speed radiographic sets, Delta value (Δ 1), was calculated (Δ1 = VATECH RVG Radiographic score – D-speed Radiographic score). A negative Δ1 value indicated a higher D-speed radiographic score than Vatech rvg score, while a positive score indicated the opposite (Table 3). Comparing the D-speed radiographic set to the VATECH RVG radiographs, 76% (39/51) of the cases showed a difference of 0.1-0.5 mm (plus or minus) of the caries extension measurement between the two radiographic sets.By comparing the D-speed radiographic scores to the clinical scores (Table 4.), it was found that 29% (15/51) of the lesions were given the same categorical score for both D speed radiographs and clinical scores. Seventy one percent of the lesions (36/51) were scored deeper into dentin clinically than their scores in the D-speed radiographic set. No lesion was scored deeper in the D-speedradiographic set than what it was clinically. For the VATECH RVG radiographic set (Table 5), 43% of the lesions (22/51) were given the same categorical score for both VATECH RVG radiographs and clinical scores. Forty nine percent of the lesions (25/51) were scored deeper into dentin clinically than their scores radiographically using the VATECH RVGsensor. Four cases out of 51 (8%) were scored deeper in the VATECH RVG radiograph images than what it was clinically The mean differences of the carious depth between the radiographic and the clinical images for each radiographic set were 0.29 mm and 0.42 mm for the VATECH RVG and D-speed images respectively.. Fig 1 presents the overall mean depth values for the D-speed, VATECH RVG radiographic sets and clinical scores.

**Table1: D-speed and RVG radiographic sets, distribution of scores.**

| Category | D- Speed | RVG |
|---|---|---|
| **0 mm** | 18(36%) | **15(30%)** |
| **0.1mm-0.5mm** | 20(40%) | **17(33%)** |
| **0.6mm-1.0mm** | 9(17%) | **10(19%)** |
| **1.1mm-1.5mm** | 4(7%) | **5(10%)** |
| **1.6mm-2mm** | 0(0) | **4(8%)** |
| **>2mm** | 0 | **0** |
| **total** | **51(100%)** | **51(100%)** |

**Table 2: Vatech RVG radiographic scores plotted against D – speed scores**

| | **Vatech RVG Radiographic series** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **D Speed radiographic series** | **In mm** | **0** | **0.1-0.5** | **0.6-1.0** | **1.1-1.5** | **1.6-2** | **>2** | **Total** |
| | 0 | 10 | 4 | 4 | | | | 18 |
| | 0.1-0.5 | 5 | 11 | 4 | | | | 20 |
| | 0.6-1.0 | | 2 | 2 | 5 | | | 9 |
| | 1.1-1.5 | | | | | 4 | | 4 |
| | 1.6-2 | | | | | | | 0 |
| | >2 | | | | | | | 0 |
| | Total | 15 | 17 | 10 | 5 | 4 | 0 | 51 |

**Table 3:Δ 1 Values comparing D-speed to RVG radiographic scores.**

| | **Δ1Values** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -0.7 | -0.6 | -0.5 | -0.4 | -0.3 | -0.2 | -0.1 | 0 | +0.1 | +0.2 | +0.3 | +0.4 | +0.5 | +0.6 | +0.7 |
| Total | 1 | 0 | 1 | 2 | 2 | 1 | 4 | 8 | 10 | 2 | 7 | 6 | 4 | 3 | 0 |

**Table 4: D-speed radiographic scores plotted against clinical scores.**

| | **D SPEED Radiographic scores** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CLINICAL SCORES** | **In mm** | **0** | **0.1-0.5** | **0.6-1.0** | **1.1-1.5** | **1.6-2** | **>2** | **Total** |
| | 0 | | | | | | | 0 |
| | 0.1-0.5 | 9 | 5 | | | | | 14 |
| | 0.6-1.0 | 7 | 12 | 4 | | | | 23 |
| | 1.1-1.5 | 1 | 4 | 2 | 6 | | | 13 |
| | 1.6-2 | | | | 1 | | | 1 |
| | >2 | | | | | | | 0 |
| | Total | 17 | 21 | 6 | 7 | 0 | 0 | 51 |

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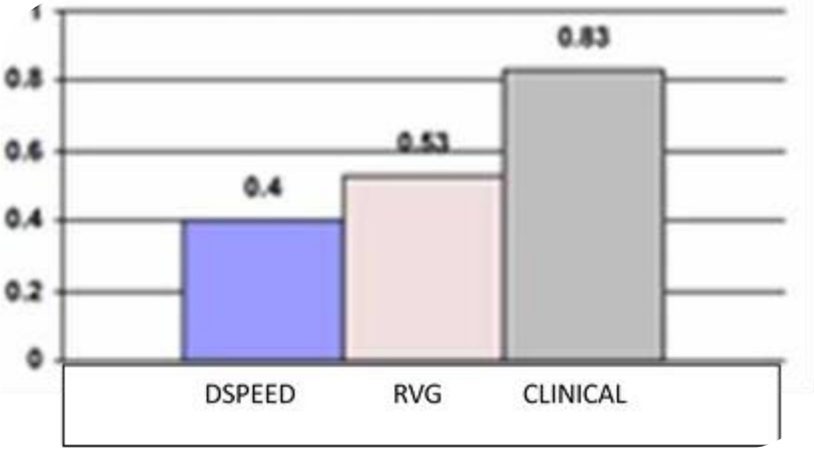
**Table 5: VATECH RVG radiographic scores plotted against clinical scores.**

| | VATECH RVG Radiographic scores | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CLINICAL SCORES | In mm | 0 | 0.1-0.5 | 0.6-1.0 | 1.1-1.5 | 1.6-2 | >2 | Total |
| | 0 | | | | | | | 0 |
| | 0.1-0.5 | 6 | 8 | | | | | 14 |
| | 0.6-1.0 | 1 | 11 | 11 | | | | 23 |
| | 1.1-1.5 | | 2 | 5 | 2 | 4 | | 13 |
| | 1.6-2 | | | | | 1 | | 1 |
| | >2 | | | | | | | 0 |
| | Total | 7 | 21 | 16 | 2 | 5 | 0 | 51 |

**Fig 1: Bar graph shows the mean depth scores in mm for D-speed, VATECH RVG and clinical images.**




**DISCUSSION**

**Radiographic vs. Clinical Findings:**The primary objective of this study was to compare the radiographic extension of initial carious lesions using VATECH RVG digital images and D-speed films to the actual clinical extension. The average clinical depth of the 51 lesions studied was 0.83 mm compared to 0.40 and 0.53 mm for the D-speed and VATECH RVG radiographs respectively. Looking at the radiographic scores plotted against the clinical scores shows that both radiographic sets underestimated the actual extension of the carious lesions in general (71% and 49% for the D-speed and VATECH RVG images respectively). The differences between the clinical and both radiographic sets were highly significant ($p<0.0001$). Therefore, the primary null hypothesis was rejected. Similar results were reported by Kooistra et al and Jesse et al[23]. The level of agreement between the D-speed sets and the clinical set in this study was 29%. Jesse et al found that 23.3% of the D-speed films agreed with the gold standard (histological sections)[23]. Kooistra et al reported similar findings using F- speed films (13% for the conservative set and 29% for the aggressive set) Thylsturp et al found that 82% of the radiographic cases in his study were scored the same as the clinical cases [24]. That study however, included the participation of 263 dentists who were not standardized. Espelid and Tveit found a level of agreement of approximately 60% in their study of extracted teeth. However, they utilized much broader scoring categories and histological validation of lesion depth[25]. Using a small category size to describe carious extension makes correlation between radiographic and clinical scoring more difficult. However, as remineralization of shallow and non-cavitated lesions has become a more highly accepted treatment option, the accurate monitoring of lesion size over timebecomes more critical. Gungor et al found that the corrected depth diagnosis for D-speed films was 55.8% and 26.8% of the films underestimated the lesions depths[26]. In that study the examiners did not quantify the lesion depth and the true depth was validated histologically. Jacobsen et al found that direct digital radiographic systems (Sidexis and Dixi) significantly underestimated the interproximal carious lesion extension [27]. In that study each of the four observers underestimated the carious lesions except one. However, the observers used a computer program to do the measurements which were validated histologically. Syriopoulos et al found that both CCD and PSP based digital radiography underestimated the carious lesion depth.

**VATECH RVG vs. D-speed radiographs:**One of the objectives of this study was to compare the diagnostic findings of the Dspeed films with that of the VATECH RVG images. Results showed that 31% (16/51) of the lesions were given the same categorical score for both radiographic sets, while 57% (29/51) were given higher scores (deeper caries extension) for VATECH RVG radiographic set compared to the D-speed set. The mean differences of the carious depth between the radiographic and the clinical images for

DOI: 10.69605/ijlbpr_13.9.2024.80

each radiographic set were 0.42 mm and 0.29 mm for the D-speed and VATECH RVG respectively. Although the difference between the two sets was not very high, it was found to be statistically significant (p= 0.0031). However, for the VATECH RVG images there is a slight curvature of the data for larger lesions, which means VATECH RVG images tend to slightly overestimate the size of larger lesions. That overestimation is not clinically significant since large lesions would have been treated based on their clinical appearance[27]. It can be concluded from these results that VATECH RVG images are more accurate in estimating the small to medium sizecarious lesions than the D-speed films. Part of this difference in the diagnostic accuracy of the VATECH RVGto estimate the carious depth could be explained by the auto enhancement and the 7x magnification (which was provided automatically by the manufacturer) compared to the D-speed films. The sensitivity table showed that 86% of the VATECH RVG images and 67% of the D-speed radiographs were able to detect the dentinal lesions. Although a great effort was made to make the x-rays at the right angle with the digital sensor, in some of the cases it was difficult for the patient to bite down completely with the digital sensor in place. This was especially true when the lesion was located closer to the front of the mouth (first premolars) due to the size and rigidity of the VATECH RVG sensor. This difference in angulation may have affected the presentation of carious lesion extension in some cases. Hintze et al found no statistical difference in their in-vitro study between the D-speed, E-speed (0.61) and RVG (0.59). However, the RVG system that was used here was the old system (1990), and the validation method was based on histological examination of the lesions. Uprichard et al in their study found that examiners were significantly more accurate in diagnosing proximal surfaces of extracted teeth using either D-speed or E-speed Plus films (0.7595, 0.7557) than they were using a CCD based direct digital system (0.5928)[28]. In that study, the examiners (five pediatric dentists) were not allowed to use the enhanced image to read the digital image. Erten et al in their in-vitro study found the sensitivity of the new RVG (0.49) system to be higher than the Ultraspeed, Ektaspeed plus and Insight (0.39, 0.48, and 0.45 111 respectively)[29]. However, the lesions were validated histologically to be present or absent using a five point scale with some lesions being confined in enamel. In this study all of the test lesions were into dentin and that was validated clinically. Various studies suggests that digital radiography imaging system performed equally well as compared to the conventional radiographic methods with respect to different types of diagnosis in the field of caries, (Nairand Nair, 2001; Wenzel,1998;
Munetaka Naitoh et al., 1998; Parissis et al., 2005) periodontal lesions, (Furkurt et al., 1992; Pass et al., 1994; Engstrom et al., 2007) endodontics (Ludlow et al., 2001; Sanderink et al., 1994), external root resorption (Kietzmann et al., 2011) and periapical lesions (Boel Kullendorff et al., 1996; Boel Kullendorff and Mats Nilsson, 1996; Rossi et al., 2007). Even though the sensitivity of E speed film and RVG DEJ mode were same, there was a decrease in specificity for the DEJ mode compared to E speed film. This could be the probable reason for not arriving at a significant association of DEJ mode in diagnosing interproximal caries Because radiographic images were displayed and assessed on a view box and digital images were viewed on a computer monitor, the type of image being viewed is obvious. This could account for the potential bias that an observer might have towards one type of imaging technique in preference to another. One might assume that digital viewing has an advantage because of its larger scale. This is not necessarily true, however the resolution capability of the monitor will determine the number of pixels and gray values displayed in the digital image. Also Matsuda et al. (1995) in their study found that higher digital image magnification reduced observer performance in the detection of aproximal caries. Since this is a comparative study, based on the evaluation of 3 observers, the observer bias should always be taken into account when analyzing the results.

## CONCLUSIONS

Within the limitations of this study, the following conclusions can be drawn that both radiographs Ultraspeed (D-speed) film and VATECH RVG size 2 super CMOS based digital radiographic sensor significantly underestimated the actual clinical extension of the carious lesions. The mean radiographic differences in estimating the carious depth compared to the true depth were 0.29 mm and 0.42 mm for the VATECH RVG and D-speed film respectively.VATECH RVG images were significantly more accurate than D-speed films in estimating of the carious lesions especially in smaller size lesions.The cavitation percentage increased as the lesion depth increased radiographically and clinically.

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Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.9.2024.80

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