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COMPARISON BETWEEN KAVO DIAGNODENT AND DIGITAL RADIOGRAPHY IN OCCLUSAL CARIES DETECTION (A DIAGNOSTIC ACCURACY STUDY)

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ABSTRACT

Aim: The aim of this study is to assess the accuracy of a laser fluorescence method "Kavo DIAGNOdent" in detecting occlusal enamel and dentinal caries in comparison with digital radiography using light microscope as gold standard.

Subjects and Methods: 44 extracted teeth were scanned by Kavo DIAGNOdent and radiographed by digital radiography. Then buccoligual sections were obtained using a water-cooled saw and examined under light microscope.

Results: For all measurements, Kavo DIAGNOdent had significantly higher percentage of correct enamel and dentinal caries diagnosis and had significantly higher sensitivity and specificity values than digital radiography ($p<0.05$).

Conclusion: According to the results of this study, Kavo DIAGNOdent is a more accurate tool than digital radiography in occlusal caries detection.

KEYWORDS: Kavo DIAGNOdent-digital radiography-vista scan-occlusal caries

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INTRODUCTION

Dental caries represents one of the main healthcare issues in dentistry and has high worldwide prevalence. Globally, 2.3 billion people suffer from dental caries, as it was ranked first among 328 diseases in adults. **(Schwendicke F.et al., 2015) & (Qin, X. et al., 2022).**

Dental caries is defined as an irreversible, progressive, and microbial disease, it affects the tooth's hard parts, which are exposed to the oral cavity. It is distinguished by the destruction of the organic component and demineralization of inorganic constituents resulting in a cavity formation **(Tantray, S et al., 2020).**

Early identification and diagnosis of dental caries is very important to reduce irreversible loss of tooth structure. The fissures in the occlusal surface are often the initial sites of caries formation. There are several methods available for detecting dental caries, including conventional, novel, and advanced techniques. Visual inspection, tactile sensation, and radiography are examples of conventional methods. While the conventional method is highly effective in detecting cavitated lesions, it may not be sufficient for identifying initial lesions. Therefore, other methods have been introduced to improve the diagnosis of initial caries, reduce the cost of treatment, and ultimately the time required to restore the teeth **(Zandona AF et al., 2009) & (Garg A et al., 2014).**

The methods include visual examination, Vista Proof, Qualitative Light Induced Fluorescence (QLF), Fluorescence camera (FC), Light induced Fluorescence (LF) as DIAGNOdent, and Digital Radiography **(Bamzahim M et al., 2004) & (Achilleos EE et al., 2013).**

In 1998, Laser fluorescence (DIAGNOdent) was introduced to the market to help in occlusal caries detection. Some studies have mentioned that DIAGNOdent's specificity and sensitivity in laboratory investigations were higher than digital radiography. Other studies have been mentioned that they are equal to each other **(Kuhnisch J et al., 2008).**

SUBJECTS AND METHOD

Study Design

This study is a diagnostic accuracy test.

Ethical Approval

Approval was obtained from the ethical committee of the faculty of dentistry, Cairo university on: 27/9/2022, approval number: 18922.

Study Setting

The extracted teeth involved in this research were collected from the department of oral and maxillofacial surgery faculty of oral and dental Medicine and Surgery, Misr University for Science and Technology. At the same settings, all the procedures of the study including extracted teeth preparations, examination by Kavo DIAGNOdent, and digital imaging procedure by sensor were managed. Gold standard detection procedure was done in external lab.

Sample Size Estimation

A power analysis was adopted to have adequate power to apply a statistical test of the null hypothesis that there is no variation would be found between tested categories. By using an alpha level of (0.05) a beta of (0.2) i.e., power=80%, a correlation coefficient in positive and negative groups of (0.5) and areas under of the curve of (0.99 and 0.80) acquired relying on the findings of prior research; the predicted size (n) was a total of (44) cases. Sample size evaluation was done using MedCalc® Statistical Software version20.019 for Windows.

Sample Selection

44 obtained posterior teeth with visually intact occlusal surfaces or occlusal carious lesions. Teeth with obvious deep cavities were excluded. The teeth were examined by visual and probing examination

(by explorer probe no.23) to select the teeth according to inclusion and exclusion criteria.

Sample Preparation

Removal of organic matters and stains from the surfaces was done by immersing the teeth in 10% solution of sodium hypochlorite for 20 min, then rinsing with distilled water for additional 20 min as done. The teeth were stored in 10% formalin in sample tubes. Sample tubes were numbered and put in sterilization pages.

Measurement of the Teeth by Kavo Diagnoddent

Each of the occlusal surface was evaluated by DIAGNOdent with a conical probe in agreement with the manufacturer's guidelines. The standard value for each tooth was calibrated before each measurement by calculating a region of sound tissue. The occlusal surfaces were carefully scanned and assessed 3 times when wet, and 3 times after being wiped with paper tissues and exposure to air for almost 2 min at room temperature. The mean values of the three data in wet and dry conditions, respectively, and the maximum value from each measurement recorded were computed. Two weeks later, the process was carried out again in the same circumstances. Figure (1)

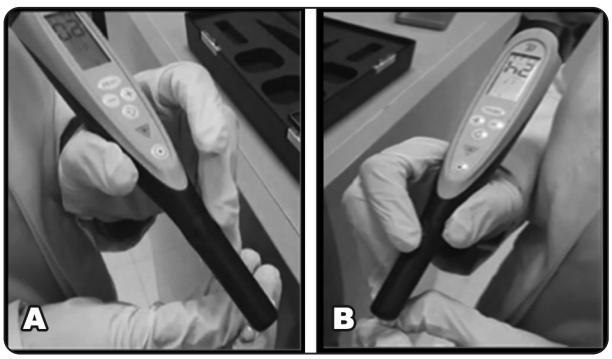

Fig. (1) A: Calibration of Kavo DIAGNOdent by measuring in sound region on buccal surface.it gave numerical value (09) which means healthy tooth structure. B: Scanning of occlusal surface.

The occlusal surfaces were photographed by digital camera. The regions with the highest values were indicated in the photos to determine the sites for the second measurement and for subsequent sectioning for light microscope examination. Figure (2)

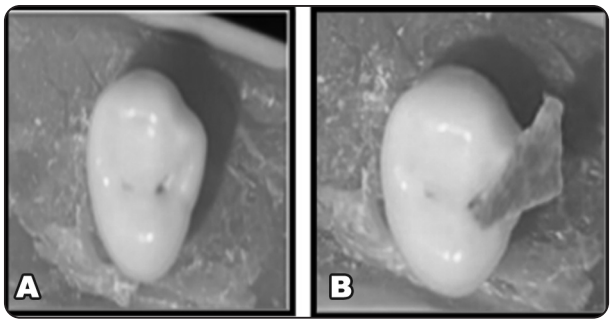

Fig. (2) A: Photograph of tooth (1). B: Identification of the site of the highest value in the tooth by a blue rubber sheet used as a pointer on the tooth.

Values: 0-10= healthy or sound tooth structure

Values: 11-20= caries in outer half of enamel

Values: 21-30= caries in inner half of enamel

Values: >30= dentinal caries.

Obtaining Dental Radiographs for the Teeth by Digital Radiography (Vista Scan)

The teeth were arranged in blocks made from wax. Dental radiographs were obtained. This was done by digital radiography. The radiographs were examined by three radiologists that were completely blinded. Figure (3)

Fig. (3) Dental radiograph of tooth (1).

Five ratings were presented to the observers, who were asked to choose one. The following scale was used: 0 =no caries, 1 =enamel caries (outer half), 2 = inner half, 3=dentinal caries (outer half), 4 = inner half.

Evaluation of the Teeth under Light Microscope

Following the laser fluorescence assessment and exposure of the digital radiographs, the teeth were removed from the blocks. At the locations indicated in the photographs, buccolingual sections approximately 300 μm thick were taken perpendicular to the occlusal surfaces using a water-cooled saw.

The slices were checked under a light microscope. Each specimen was photographed using Stereomicroscope (Nikon Eclips E600, Tokyo, Japan) with a built-in camera. The photos were taken with the; Digital camera with resolution of 3Mega Pixels, located vertically at a distance of 2.5 cm from the samples. The angle between the lens axis and the illumination source is almost 90°. The images were taken at maximum resolution using a fixed magnification of 40X.The images were saved to a compatible personal computer with a resolution of 1280 × 1024 pixels per image. figure (4)

Fig. (4) Image of tooth (1) The lesion depth was scored on a scale from 0 to 4, where 0 = sound structure, 1 = enamel caries (outer), 2 = enamel caries (inner), 3 = dentinal caries (outer), and 4 =dentinal caries (inner).

Blinding & Inter and Intra-Observer Agreement

The assessment was done by three oral radiologists with different experience and one periodontist. The evaluation of dental radiographs was done by three radiologist. The evaluation of the teeth by DIAGNOdent was done by the researcher and the periodontist. All observers were blind to the results of each other.

Statistical Analysis

Qualitative data were expressed as number and percentage. Inter-modality agreement was analyzed using Cohen's kappa coefficient while inter-observer agreement was analyzed using Fleiss' kappa coefficient. Values of both coefficients were interpreted following **(Landis 1977).** Difference between testing modalities was analyzed using McNemar's test while the difference in diagnostic accuracy was analyzed using the test devised by **(Hawass, N. E.1997)** .The significance level was set at $p<0.05$ for all tests. The analysis was carried out with R statistical analysis software version 4.3.2 for Windows **(R Core Team 2023).**

RESULTS

Accuracy of radiography:

Diagnostic accuracy of digital radiography in caries detection is presented in tables from (1) and (2) and in figure (5)

Digital radiography measurements were made by three observers and there was a substantial agreement between their measurements ($\varkappa$=0.737, $p<0.001$). For enamel caries, 18 cases out of 44 were misclassified, while for dentinal caries 17 cases were misclassified. For both types, there was no significant agreement between digital radiography and light microscope evaluation ($p>0.05$). For enamel caries detection, sensitivity (true positive rate) was (33.33%), specificity (true negative rate) was (60.98%), positive predictive value (the probability that a positive diagnosis is correct) was (5.88%), negative predictive value (the probability that a negative diagnosis is correct) was (92.59%), and the overall accuracy (the probability of true diagnosis) was (59.09%). For dentinal caries detection, sensitivity was (30.00%), specificity was (87.50%), PPV was (66.67%), NPV was (60.00%), and the overall accuracy was (61.36%).

TABLE (1) Agreement between digital radiography and light microscopic evaluation.

Parameter	Light microscope	Digital radiography [n (%)]		Cohen's kappa (95% CI)	p-value
		No	Yes		
Enamel caries	No	25 (92.59%)	16 (94.12%)	-0.018 (-0.390:0.354)	0.845ns
	Yes	2 (7.41%)	1 (5.88%)		
Dentinal caries	No	21 (60.00%)	3 (33.33%)	0.183 (-0.129:0.496)	0.152ns
	Yes	14 (40.00%)	6 (66.67%)		

CI= confidence interval, *; significant (p<0.05).

TABLE (2) Diagnostic accuracy of digital radiography.

Parameter	Enamel caries	Dentinal caries
Sensitivity (95% CI)	33.33% (0.84%:90.57%)	30.00% (11.89%:54.28%)
Specificity (95% CI)	60.98% (44.50%:75.80%)	87.50% (67.64%:97.34%)
PPV (95% CI)	5.88% (0.15%:28.69%)	66.67% (29.93%:92.51%)
NPV (95% CI)	92.59% (75.71%:99.09%)	60.00% (42.11%:76.13%)
Accuracy (95% CI)	59.09% (43.25%:73.66%)	61.36% (45.50%:75.64%)

CI= confidence interval.

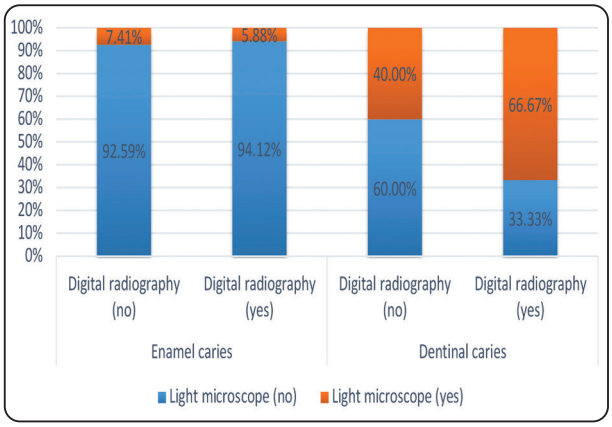

Fig. (5) Stacked bar chart showing the agreement between digital radiography and light microscopic evaluation.

Accuracy of Diagnodent:

Diagnostic accuracy of Diagnodent in caries detection is presented in tables from (3) to (6) and in figure (6)

A- First measurement:

Wet:

For enamel caries, 5 cases out of 44 were misclassified and there was a moderate statistically significant agreement between both modalities (k=0.495, p<0.001), while for dentinal caries 4 cases were misclassified and the agreement was strong (k=0.814, p<0.001). For enamel caries detection, sensitivity was (100.00%), specificity was (87.80%), PPV was (37.50%), NPV was (100.00%), and the overall accuracy was (88.64%). For dentinal caries detection, sensitivity was (80.00%), specificity was (100.00%), PPV was (100.00%), NPV was (85.71%), and the overall accuracy was (90.91%).

Dry:

For enamel caries, 6 cases out of 44 were misclassified and there was a moderate statistically significant agreement between both modalities (k=0.443, p<0.001), while for dentinal caries 4 cases were misclassified and the agreement was strong (k=0.814, p<0.001). For enamel caries detection, sensitivity was (100.00%), specificity was (85.37%), PPV was (33.33%), NPV was (100.00%), and the overall accuracy was (86.36%). For dentinal caries detection, sensitivity was (80.00%), specificity was (100.00%), PPV was (100.00%), NPV was (85.71%), and the overall accuracy was (90.91%).

B- Second measurement:

Wet:

For enamel caries, 6 cases out of 44 were misclassified and there was a moderate statistically significant agreement between both modalities (k=0.443, p<0.001), while for dentinal caries 3 cases were misclassified and the agreement was strong (k=0.861, p<0.001). For enamel caries detection, Sensitivity was (100.00%), specificity was (85.37%), PPV was (33.33%), NPV was (100.00%), and the overall accuracy was (86.36%). For dentinal caries detection, sensitivity was (85.00%), specificity was (100.00%), PPV was (100.00%), NPV was (88.89%), and the overall accuracy was (93.18%).

Dry:

For enamel caries, 5 cases out of 44 were misclassified and there was a moderate statistically significant agreement between both modalities (k=0.495, p<0.001), while for dentinal caries 3 cases were misclassified and the agreement was strong (k=0.861, p<0.001). For enamel caries detection, sensitivity was (100.00%), specificity was (87.80%), PPV was (37.50%), NPV was (100.00%), and the overall accuracy was (88.64%). For dentinal caries detection, sensitivity was (85.00%), specificity was (100.00%), PPV was (100.00%), NPV was (88.89%), and the overall accuracy was (93.18%).

TABLE (3) Agreement between Diagnodent and light microscopic evaluation (first measurement).

Status	Parameter	Light microscope	Diagnodent [n (%)]		Cohen's kappa (95% CI)	p-value
			No	Yes		
Wet	Enamel caries	No	36 (100.00%)	5 (62.50%)	0.495 (0.067:0.924)	<0.001*
		Yes	0 (0.00%)	3 (37.50%)		
	Dentinal caries	No	24 (85.71%)	0 (0.00%)	0.814 (0.634:0.993)	<0.001*
		Yes	4 (14.29%)	16 (100.00%)		
Dry	Enamel caries	No	35 (100.00%)	6 (66.67%)	0.443 (0.017:0.869)	<0.001*
		Yes	0 (0.00%)	3 (33.33%)		
	Dentinal caries	No	24 (85.71%)	0 (0.00%)	0.814 (0.634:0.993)	<0.001*
		Yes	4 (14.29%)	16 (100.00%)		

CI= confidence interval, *; significant (p<0.05).

TABLE (4) Agreement between Diagnodent and light microscopic evaluation (second measurement).

Status	Parameter	Light microscope	Diagnodent [n (%)]		Cohen's kappa (95% CI)	p-value
			No	Yes		
Wet	Enamel caries	No	35 (100.00%)	6 (66.67%)	0.443 (0.017:0.869)	<0.001*
		Yes	0 (0.00%)	3 (33.33%)		
	Dentinal caries	No	24 (88.89%)	0 (0.00%)	0.861 (0.704:1.000)	<0.001*
		Yes	3 (11.11%)	17 (100.00%)		
Dry	Enamel caries	No	36 (100.00%)	5 (62.50%)	0.495 (0.067:0.924)	<0.001*
		Yes	0 (0.00%)	3 (37.50%)		
	Dentinal caries	No	24 (88.89%)	0 (0.00%)	0.861 (0.704:1.000)	<0.001*
		Yes	3 (11.11%)	17 (100.00%)		

CI= confidence interval, *; significant (p<0.05).

TABLE (5) Diagnostic accuracy of Diagnodent (first measurement).

Status	Parameter	Enamel caries	Dentinal caries
Wet	Sensitivity (95% CI)	100.00% (29.24%:100.00%)	80.00% (56.34%:94.27%)
	Specificity (95% CI)	87.80% (73.80%:95.92%)	100.00% (85.75%:100.00%)
	PPV (95% CI)	37.50% (8.52%:75.51%)	100.00% (79.41%:100.00%)
	NPV (95% CI)	100.00% (90.26%:100.00%)	85.71% (67.33%:95.97%)
	Accuracy (95% CI)	88.64% (75.44%:96.21%)	90.91% (78.33%:97.47%)
Dry	Sensitivity (95% CI)	100.00% (29.24%:100.00%)	80.00% (56.34%:94.27%)
	Specificity (95% CI)	85.37% (70.83%:94.43%)	100.00% (85.75%:100.00%)
	PPV (95% CI)	33.33% (7.49%:70.07%)	100.00% (79.41%:100.00%)
	NPV (95% CI)	100.00% (90.00%:100.00%)	85.71% (67.33%:95.97%)
	Accuracy (95% CI)	86.36% (72.65%:94.83%)	90.91% (78.33%:97.47%)

CI= confidence interval.

TABLE (6) Diagnostic accuracy of Diagnodent (second measurement).

Status	Parameter	Enamel caries	Dentinal caries
Wet	Sensitivity (95% CI)	100.00% (29.24%:100.00%)	85.00% (62.11%:96.79%)
	Specificity (95% CI)	85.37% (70.83%:94.43%)	100.00% (85.75%:100.00%)
	PPV (95% CI)	33.33% (7.49%:70.07%)	100.00% (80.49%:100.00%)
	NPV (95% CI)	100.00% (90.00%:100.00%)	88.89% (70.84%:97.65%)
	Accuracy (95% CI)	86.36% (72.65%:94.83%)	93.18% (81.34%:98.57%)
Dry	Sensitivity (95% CI)	100.00% (29.24%:100.00%)	85.00% (62.11%:96.79%)
	Specificity (95% CI)	87.80% (73.80%:95.92%)	100.00% (85.75%:100.00%)
	PPV (95% CI)	37.50% (8.52%:75.51%)	100.00% (80.49%:100.00%)
	NPV (95% CI)	100.00% (90.26%:100.00%)	88.89% (70.84%:97.65%)
	Accuracy (95% CI)	88.64% (75.44%:96.21%)	93.18% (81.34%:98.57%)

CI= confidence interval.

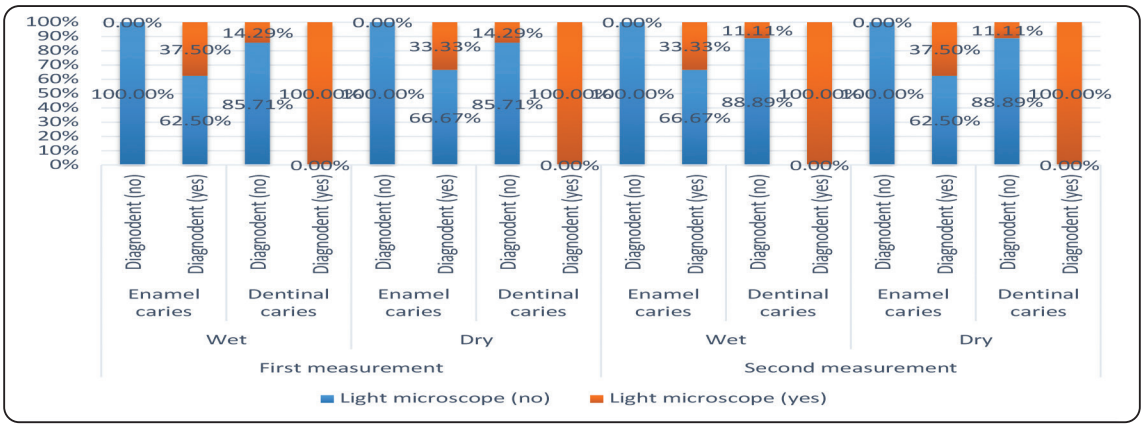

Fig. (6) Stacked bar chart showing the agreement between Diagnodent and light microscopic evaluation.

3- Agreement between Diagnodent wet and dry measurements:

Agreement between Diagnodent wet and dry measurements is presented in tables from (7) and in figure (7).

For second and first measurements, there was a statistically significant substantial and almost perfect agreement between wet and dry measurements with enamel and dentinal caries detection respectively (p<0.001).

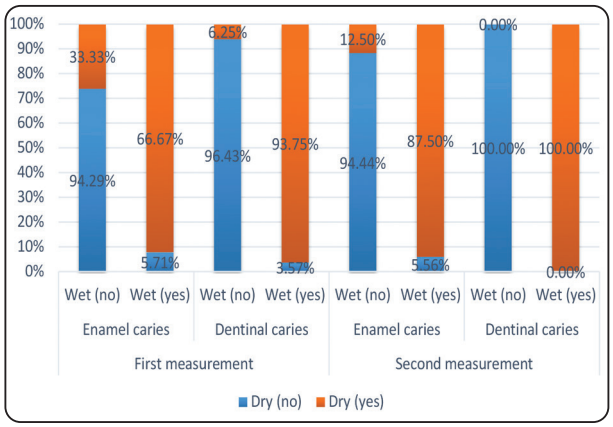

Fig. (7) Stacked bar chart showing the agreement between Diagnodent wet and dry measurements.

TABLE (7) Agreement between Diagnodent wet and dry measurements.

Time	Parameter	Diagnodent (wet)	Diagnodent (dry) [n (%)]		Cohen's kappa (95% CI)	p-value
			No	Yes		
First	Enamel caries	No	33 (94.29%)	3 (33.33%)	0.636 (0.326:0.945)	<0.001*
		Yes	2 (5.71%)	6 (66.67%)		
	Dentinal caries	No	27 (96.43%)	1 (6.25%)	0.902 (0.765:1.000)	<0.001*
		Yes	1 (3.57%)	15 (93.75%)		
Second	Enamel caries	No	34 (94.44%)	1 (12.50%)	0.781 (0.536:1.000)	<0.001*
		Yes	2 (5.56%)	7 (87.50%)		
	Dentinal caries	No	27 (100.00%)	0 (0.00%)	1.000 (1.000:1.000)	<0.001*
		Yes	0 (0.00%)	17 (100.00%)		

CI= confidence interval, *; significant (p<0.05).

4- Agreement between Diagnodent first and second measurements:

Agreement between Diagnodent first and second measurements is presented in tables from (8) and in figure (8).

For wet measurements, there was a statistically significant substantial agreement between both measurements regarding enamel caries detection (k=0.636, p<0.001). For wet enamel caries detection, the agreement was moderate (k=0.490, p<0.001), while for dentinal caries, the agreement was almost perfect (k>0.9, p<0.001).

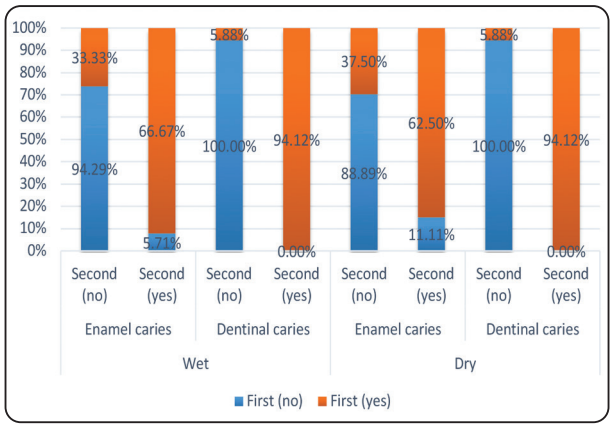

Fig. (8) Stacked bar chart showing the agreement between Diagnodent first and second measurements.

TABLE (8) Agreement between Diagnodent first and second measurements.

Status	Parameter	Diagnodent (first)	Diagnodent (second) [n (%)]		Cohen's kappa (95% CI)	p-value
			No	Yes		
Wet	Enamel caries	No	33 (94.29%)	3 (33.33%)	0.636 (0.326:0.945)	<0.001*
		Yes	2 (5.71%)	6 (66.67%)		
	Dentinal caries	No	27 (100.00%)	1 (5.88%)	0.952 (0.855:1.000)	<0.001*
		Yes	0 (0.00%)	16 (94.12%)		
Dry	Enamel caries	No	32 (88.89%)	3 (37.50%)	0.490 (0.134:0.847)	<0.001*
		Yes	4 (11.11%)	5 (62.50%)		
	Dentinal caries	No	27 (100.00%)	1 (5.88%)	0.952 (0.855:1.000)	<0.001*
		Yes	0 (0.00%)	16 (94.12%)		

CI= confidence interval, *; significant (p<0.05).

5- Difference in diagnostic accuracy between the digital radiography and Diagnodent:

Difference in diagnostic accuracy between the digital radiography and Diagnodent is presented in tables from (9) to (12) and in figure (9)

For all measurements, Diagnodent had significantly higher percentage of correct enamel and dentinal caries diagnoses and had significantly higher sensitivity and specificity values than digital radiography (p<0.05).

TABLE (9) Difference in diagnostic accuracy between the digital radiography and Diagnodent (first measurement) (A).

Status	Parameter	Diagnosis	[n (%)]		p-value
			Digital radiography	Diagnodent	
Wet	Enamel caries	Correct	26 (59.09%)	39 (88.64%)	0.006*
		False	18 (40.91%)	5 (11.36%)	
	Dentinal caries	Correct	27 (61.36%)	40 (90.91%)	0.001*
		False	17 (38.64%)	4 (9.09%)	
Dry	Enamel caries	Correct	26 (59.09%)	38 (86.36%)	0.010*
		False	18 (40.91%)	6 (13.64%)	
	Dentinal caries	Correct	27 (61.36%)	40 (90.91%)	0.001*
		False	17 (38.64%)	4 (9.09%)	

; significant (p<0.05).

TABLE (10) Difference in diagnostic accuracy between the digital radiography and Diagnodent (second measurement) (A).

Status	Parameter	Diagnosis	[n (%)]		p-value
			Digital radiography	Diagnodent	
Wet	Enamel caries	Correct	26 (59.09%)	38 (86.36%)	0.019*
		False	18 (40.91%)	6 (13.64%)	
	Dentinal caries	Correct	27 (61.36%)	41 (93.18%)	0.001*
		False	17 (38.64%)	3 (6.82%)	
Dry	Enamel caries	Correct	26 (59.09%)	39 (88.64%)	0.006*
		False	18 (40.91%)	5 (11.36%)	
	Dentinal caries	Correct	27 (61.36%)	41 (93.18%)	0.001*
		False	17 (38.64%)	3 (6.82%)	

; significant (p<0.05).

TABLE (11) Difference in diagnostic accuracy between the digital radiography and Diagnodent (first measurement) (B).

Status	Caries	Parameter	Value (95% CI)	p-value
Wet	Enamel caries	Difference in sensitivity	66.67% (-100.00%:-13.32%)	0.010*
		Difference in specificity	26.83% (-44.75%:-8.91%)	
	Dentinal caries	Difference in sensitivity	50.00% (-71.91%:-28.09%)	0.002*
		Difference in specificity	12.50% (-25.73%:0.73%)	
Dry	Enamel caries	Difference in sensitivity	66.67% (-100.00%:-13.32%)	0.016*
		Difference in specificity	24.39% (-41.99%:-6.79%)	
	Dentinal caries	Difference in sensitivity	50.00% (-71.91%:-28.09%)	0.002*
		Difference in specificity	12.50% (-25.73%:0.73%)	

CI= confidence interval, *; significant (p<0.05).

TABLE (12) Difference in diagnostic accuracy between the digital radiography and Diagnodent (second measurement) (B).

Status	Caries	Parameter	Value	p-value
Wet	Enamel caries	Difference in sensitivity	66.67% (-100.00%:-13.32%)	0.030*
		Difference in specificity	24.39% (-44.42%:-4.36%)	
	Dentinal caries	Difference in sensitivity	55.00% (-76.80%:-33.20%)	<0.001*
		Difference in specificity	12.50% (-25.73%:0.73%)	
Dry	Enamel caries	Difference in sensitivity	66.67% (-100.00%:-13.32%)	0.010*
		Difference in specificity	26.83% (-44.75%:-8.91%)	
	Dentinal caries	Difference in sensitivity	55.00% (-76.80%:-33.20%)	<0.001*
		Difference in specificity	12.50% (-25.73%:0.73%)	

CI= confidence interval, *; significant (p<0.05).

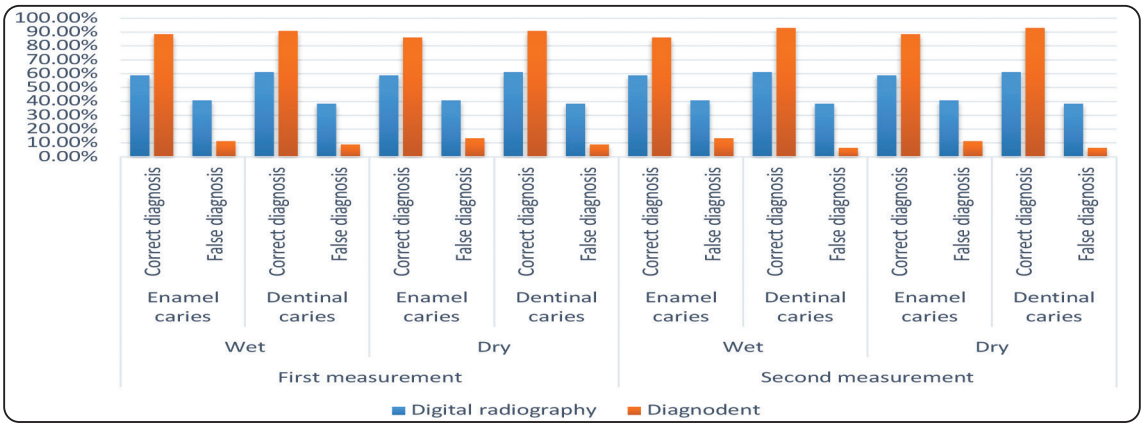

Fig (9) Stacked bar chart showing the difference in diagnostic accuracy between the digital radiography and Diagnodent.

DISCUSSION

The current research was conducted to identify the accuracy of Kavo DIAGNOdent in occlusal caries detection in comparison with digital radiography and stereomicroscope (light microscope) was used as gold standard. Regarding accuracy of digital radiography, in the current work the digital radiography assessment was made by three observers and there was a substantial agreement between their readings ($\varkappa$=0.737, p<0.001), There was no significant agreement between digital radiography and light microscope evaluation (p>0.05). The accuracy of digital systems is comparable in the diagnosis of caries, it relies on the experience of the dentists, not the imaging modality (**Srilatha, A., et al., 2019).**

A study done by **(Minuesa-García, E., et al., 2022)** to evaluate the efficacy of international caries detection and assessment system (ICDAS), digital radiography, and DIAGNOdent fluorescence laser pen for diagnosing occlusal caries lesions. They used histological section as gold standard. They found that international caries detection and assessment system (ICDAS) and DIAGNOdent are better diagnostic methods than digital radiography in detecting occlusal caries.

In the research carried out by **(Ghoncheh, Z., et al., 2017)**, they concluded that digital radiography and DIAGNOdent have equal diagnostic efficacy in detecting secondary proximal caries adjacent to composite restorations, that result about accuracy of DIAGNOdent doesn't agree with our study and that may be due to using different gold standard and they detected secondary proximal caries. Also the authors suggested to conduct more studies in the future to evaluate the efficacy of DIAGNOdent and digital radiographs in detecting secondary proximal caries.

Also research done by **(Menem, R., et al., 2017)** concluded that the LFpen was found to be more accurate than digital bitewing radiography. The findings of the above mentioned work was in accordance with the results of ours despite of using the visual-tactile inspection as reference standard and evaluated the efficacy of DIAGNOdent and digital radiographs in detecting of proximal caries.

Regarding the difference in diagnostic accuracy between the digital radiography and DIAGNOdent, for all measurements, DIAGNOdent had significantly higher percentage of correct enamel and dentinal caries diagnoses and had potentially higher sensitivity and specificity values than digital radiography ($p<0.05$).

In research performed by **(Alammar, R., et al., 2020)**, they concluded that the accuracy of DIAGNOdent is higher than digital bitewing radiography in detecting of caries .This is found to be in agreement with the finding of our study.

Another study done by **(Javed, F., et al., 2020).** revealed that DIAGNOdent was found to be helpful tools that can be used in the early detection of caries more than traditional visual and radiographic examinations.

In the study carried out by **(Meirelles, J. B., et al., 2022)** to compare different methods used in the diagnosis of pigmented pits and fissures on the occlusal surface in an in vitro study. They concluded that visual inspection yielded better findings in terms of sensitivity and specificity compared to fluorescent laser and radiographic methods so we used visual and probing evaluation in our study with Kavo DIAGNOdent in occlusal caries detection to obtain the best results. ICDAS and DIAGNOdent are better diagnostic strategies than radiographs in detecting occlusal caries and for better diagnosis, we can use a combination of the two methods in occlusal caries detection as suggested by (**Minuesa-García, E., et al., 2022).**

DIAGNOdent pen is an effective method that can be used in the detection of caries, but other factors should be considered. We should follow manufacturer's instructions carefully and calibration method as DIAGNOdent pen measurements are known to be influenced by in vitro and in vivo conditions, storing time and temperature, preservative solutions, polishing pads, tooth humidity, application type of the device, and correct calibration of the device, leading to variations in cutoff points **(Kockanat, A., et al.,2017).**

CONCLUSION:

1- "Kavo DIAGNOdent" is accurate in detecting occlusal enamel and dentinal caries.

2- DIAGNOdent should be used with visual examination.

3- DIAGNOdent should be used carefully, following manufacturer's instructions and well trained dentists.

Conflict of Interest:

There is no conflict of interest.

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