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Assessment of dental photography imaging as a diagnostic tool for incipient pits and fissures caries in permanent posterior teeth

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Abstract: Concurrently, dentistry has embraced technological advancements, incorporating digital imaging techniques in various applications [1]. This crossover study aimed to assess digital dental photography imaging as a diagnostic tool for detecting incipient pits and fissure carious lesions in permanent teeth and its correlations with traditional visual examination according to ICDAS II. Direct intraoral clinical examinations were conducted by two AEGD residents and two calibrated restorative consultants trained in the ICDAS II grading system. A total of 34 occlusal surfaces of premolars and molars were examined. Only healthy teeth, enamel hypomineralization, and non-cavitated carious surfaces were included. Non-carious hard tissue defects, fissure sealants, and direct and indirect restorations were excluded. The digital photographs were obtained by two examiners and then blindly assessed in a presentation room using a large screen. The actual scoring of pit and fissure carious lesions in 18 extracted premolar teeth was examined under a clinical microscope based on the downer histological examination. Sensitivity and positive predictive value were highest in photographic examination compared with visual in three observers, while specificity and negative predictive value were equal between visual and photographic examination. From the survey, we compared differences in caries and non-caries detection between PAADI Instructors and PAADI Residents using the Mann-Whitney U test. Residents are more likely to overestimate the results compared with the instructors (P value < 0.05). The Az values for the different examination methods compared with the gold standard (histologic examination) were calculated. The Az values of the two examiners (Consultant 2 and Resident 1) were highest for the visual examination, while it was highest for the photographic examination for Consultant 1 and Resident 2. Visual clinical examination should be the standard for detecting incipient occlusal pit and fissure carious lesions, and digital photographic imaging is a valid diagnostic tool as well.

Keywords: *Dental photography, Incipient caries, Permanent posterior teeth.*

1. Introduction

Dental caries remains a widespread chronic condition that can result in dental deterioration if not addressed. By the age of 30, more than 90% of adults in the United States have encountered dental caries [2, 3]. The high occurrence rate is partially attributed to the fact that early-stage caries can progress undetected before evolving into cavities. As a result, research should focus on the early and accurate detection of incipient caries [4]. Radiography often underestimates carious lesion depth and has low sensitivity, particularly for detecting early-stage incipient caries [5]. Occlusal pits and fissures

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caries may present a diagnostic challenge for dental professionals, especially when the lesion has extended into the dentin layer [6].

The early detection of dental caries is crucial for preventive strategies [7]. Visual-tactile examination, the most common diagnostic method in daily clinical practice, is essential for caries detection. In 2005, the International Caries Detection and Assessment System (ICDAS II) was introduced as a scoring system for caries lesion detection, providing an evidence-based tool for clinicians, researchers, and epidemiologists. To facilitate visual examination using artificial intelligence algorithms, digital images are the preferred choice for analyzing tooth surfaces.

With the advancement in technology, digital photographs have been employed in the dentistry field in many different ways [1]. The precise description of caries stages following ICDAS II criteria has helped dental photography become more popular in the cariology field [8, 9]. A review of the literature revealed that photographic image analysis demonstrated higher sensitivity in detecting dental caries compared to visual examination of extracted permanent teeth [10]. Furthermore, Umemori and colleagues determined that digital image analysis of occlusal surfaces could serve as an effective diagnostic tool for tooth decay, achieving 86% sensitivity and specificity [11]. Current recommendations suggest using Digital Single Lens Reflex (DSLR) cameras for dental photography [12] and the resulting digital images are used to diagnose caries lesions and other dental conditions [8, 9].

Discrepancies often arise between clinical decisions and high-contrast dental photography in comprehensive case presentations at Prince Abdulrahman Advanced Dental Institute (PAADI) regarding pit and fissure caries diagnosis. This article aims to detect and assess occlusal incipient pit and fissure caries lesions in permanent teeth using professional digital dental photography and compare these findings to direct visual examination. Additionally, it seeks to evaluate feedback on incipient carious lesions detected by restorative faculty members and AEGD residents during comprehensive case presentations. Finally, it aims to validate the actual scoring of the occlusal incipient pit and fissure caries lesions performed on extracted premolar teeth after sectioning with a diamond disc and microscopic observation.

2. Research Methods

This crossover clinical study was conducted at Prince Abdulrahman Advanced Dental Institute (PAADI) in dental clinics in Riyadh. From 2022 to 2023.

The research committee at the Prince Abdulrahman Advanced Dental Institute (PAADI) in Riyadh granted ethical approval before the commencement of this investigation. This authorization was obtained as a necessary prerequisite to conducting the study. All participants in this research provided their written consent before their involvement in the study. The age group ranged from 18 years to 60 years for males and females, where the permanent teeth completely erupted, excluding the third molar. The research methodologies are classified into three categories, as shown in Figure 1.

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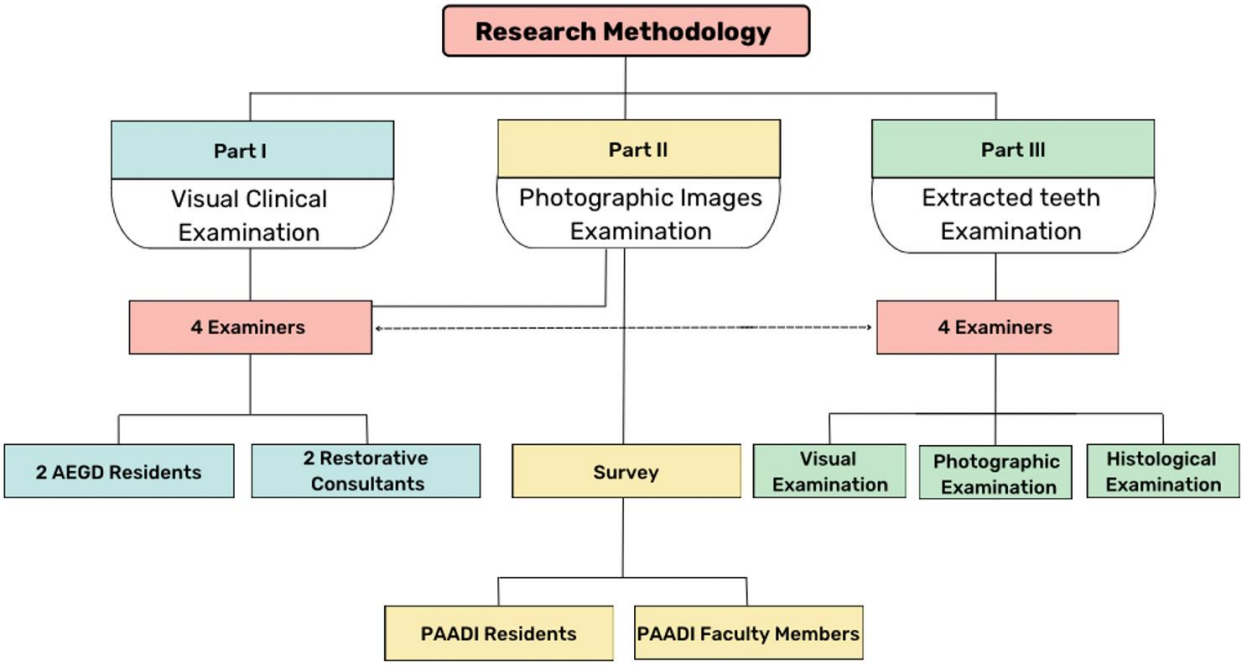

Figure 1.
The research methodology.

2.1. Part I: Visual Clinical Examination

Two Advanced Education in General Dentistry (AEGD) residents and two calibrated restorative consultants performed oral examinations. These examinations were conducted in a dental facility utilizing the illumination provided by a dental unit. Before the examination, thorough cleaning and drying of tooth surfaces. The occlusal pit and fissure surface were assessed using a dental mirror and the air/water syringe attached to the dental chair unit. During a visual examination, a sharp dental explorer is not permitted. All the examiners used the X3.5 magnification dental loupe (Univet, Italy). This examination aimed to determine whether these areas were healthy or exhibited signs of carious lesions. The extent of dental lesions was documented using the International Caries Detection and Assessment System II (ICDAS II) criteria, as outlined in Table 1. The study included only healthy teeth, that exhibited enamel hypomineralization, or had uncavitated carious surfaces. To prevent potential evaluation bias, the researchers excluded non-carious hard tissue defects (such as hypoplasia, erosion, or tooth wear), fissure sealants, and both direct and indirect restorations. Specifically, ICDAS II codes 3, 4, and 6 were not considered in this investigation. All data were recorded in a designated form, which included the patient's identification numbers and the corresponding tooth number.

Table 1.
Explanation of the second digit employed in encoding the ICDAS II criteria [13].

ICDAS II Criteria	
0	**No visual signs of carious lesions or any enamel defect**
1	First visible changes in the enamel Visible only after drying with air Changes in coloration confined to areas of pits
2	Change in visible enamel even in the presence of moisture More extensive and not restricted to pits
3	Destruction located in enamel without visible dentin Discontinuities of enamel structure
4	Dark shadow on the underlying dentin with or without localized destruction of enamel
5	Clear cavity with visible dentin

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	Cavity that involves less than half the dental surface
6	Extensive cavity evident in dentin Cavity deep and wide involves more than half of the tooth

2.2. Part II: Photographic Images

The photographs were obtained by two examiners AEGD residents. Thirty-four molar and premolar teeth were photographed with a professional DSLR camera (EOS Canon 800D, f/2.8L Macro 100-mm lens) and Macro ring Flash (YN14EX, YONGNUO) after tooth cleaning and drying. The patients were positioned in a reclined dental chair to minimize movement during image capture. Indirect photography of molars and premolars was accomplished using intraoral mirrors. These mirrors were preheated before placement in the oral cavity to prevent moisture condensation on their surfaces, ensuring clear visibility. The photographs were taken in 1:2 magnification using f/23 aperture and 1/200 shutter speed based on the best results obtained as shown in Figure 2.

Figure 2.
Photograph taken by 1:2 magnification.

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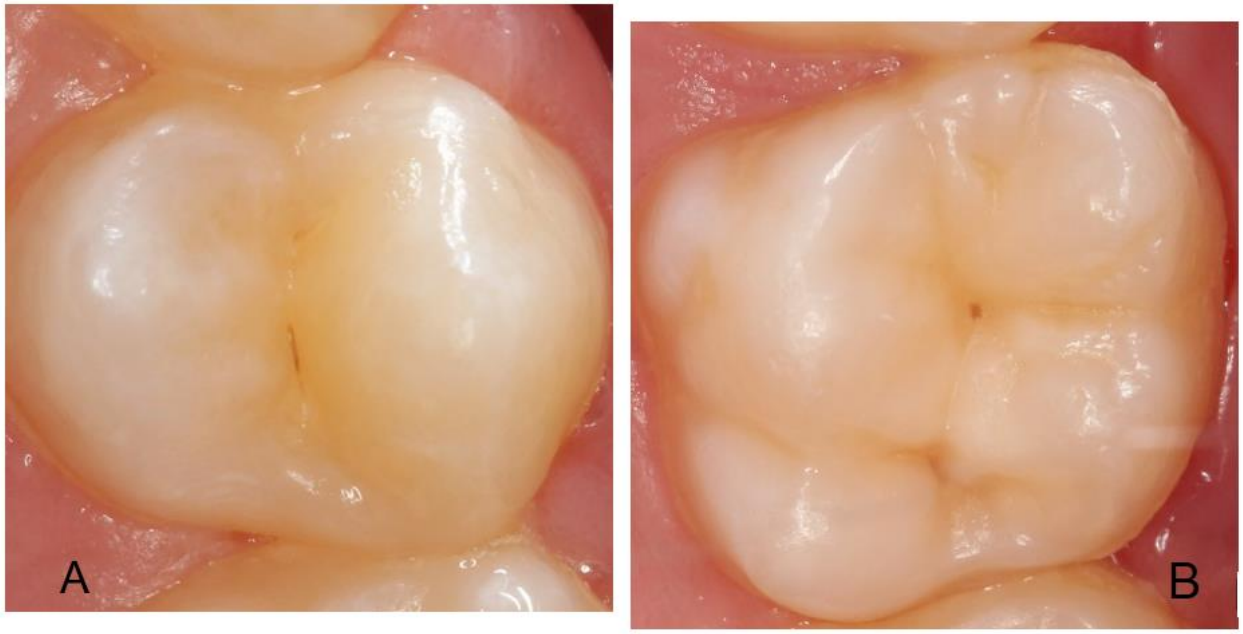

Figure 3.
After editing and cropping to 1:1 magnification.
A: premolar upper left side,1200 × 1200 pixels.
B: molar upper left side,1500 × 1500 pixels.

To ensure the highest quality of imagery, the study excluded photographs that failed to meet specific criteria, including those that were out of focus or contaminated with saliva. Furthermore, the researchers refined the dataset by removing any redundant images of identical teeth or dental surfaces. This process of image selection and refinement was implemented to maintain the integrity and reliability of the visual data used in the research. The intraoral camera was linked to a portable computer, enabling immediate preview of each captured image before storing it in the patient's designated digital folder, categorized by patient identification and tooth numbers. The digital photographs were subsequently saved as JPEG files on a personal computer for future retrieval and examination. The JPEG images were standardized using professional image editing software. For premolars, the resolution was set to 1,200 × 1,200 pixels, while molars were adjusted to 1,500 × 1,500 pixels, with no compression applied. The images were then rotated to a uniform orientation and cropped to achieve a 1:1 magnification ratio, as illustrated in Figure 3. The final step involved ensuring that the tooth surface occupied the majority of the frame before examination.

The photographs were initially examined at their original dimensions, with the option to utilize a magnification tool for enhanced clarity as needed. Two AEGD residents and two restorative consultants conducted clinical examinations of all assigned teeth. Subsequently, they independently re-examined the images in a presentation room equipped with large display screens. Following the photographic analysis, residents and consultants completed a special form, noting their respective patient identification numbers and examined tooth numbers. PAADI residents and faculty members were then presented with the photographs in the same room with the large screen. They documented their observations regarding the condition of pits and fissures on a special form, which included patient identification and tooth numbers. Sound teeth were used as a control group for comparison purposes.

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2.3. Part Iii: Extracted Teeth

2.3.1. Sample Selection and Preparation

Following orthodontic assessment for treatment involving premolar extractions, patients or their legal representatives provided signed and verbal consent for oral surgery. The individuals who supplied the teeth consented to their utilization in non-DNA dental research. After use, the human tissue samples were discarded in compliance with ethical protocols.

The team of evaluators, consisting of two Advanced Education in General Dentistry (AEGD) residents and two restorative consultants, examined eighteen extracted permanent premolars to identify non-cavitated caries lesions in pits and fissures. The assessment was conducted using two distinct methodologies: visual inspection using a dental loupe with 3.5x magnification, and analysis of images captured by a digital single-lens reflex (DSLR) camera.

The study selected teeth exhibiting uncavitated carious lesions and untreated premolars. Specimens with visible restorations, cracks, fractures, occlusal calculus, or advanced caries lesions characterized by exposed dentin and significant discoloration were excluded from the investigation. Each dental specimen was assigned a unique numerical identifier for reference purposes. After extraction, all premolars are stored in a thymol-infused saline solution maintained at 4°C. This method ensures the teeth remain hydrated and prevents the proliferation of bacteria. The occlusal surfaces were subsequently cleaned utilizing a conical brush attachment on a low-speed handpiece, employing a prophylactic polishing paste. They were then positioned in 9 × 11 mm vinyl polysiloxane silicone blocks at the cervical level, mimicking their natural anatomical position, as shown in Figure 4. Before examination, each tooth was dehydrated using cotton rolls. The evaluation and grading methodology utilized the ICDAS II standards for assessment.

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Figure 4.
Mounted extracted tooth in vinyl polysiloxane blocks at the cervical level

2.3.2. Histological Examination (Photographic Procedure and Validation of the Actual Scores)

The digital camera was secured in a stationary position using a clamp, oriented vertically above the occlusal surface to achieve a 1:1 magnification ratio. The camera settings were configured with an aperture of f/32 and a shutter speed of 1/200. Each tooth's digital image was captured and stored using the corresponding identification numbers, as illustrated in Figure 5. The extracted dental specimens were divided using a diamond-edged cutting instrument, with the incision made from the mesial aspect to the distal aspect as illustrated in Figure 6. Subsequently, the newly exposed dental surface underwent polishing and dried procedures. The histological section for each tooth was assessed by the 4 examiners (two AEGD residents and the two restorative consultants) under the clinical microscope as shown in Figure 7. The diagnostic validation of actual scores was performed by Downer histological examination as shown in Table 2.

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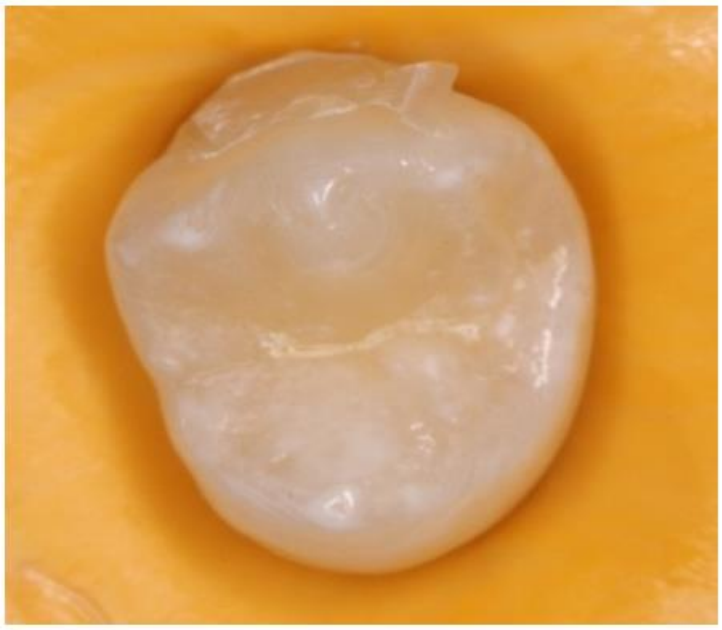

Figure 5.
Photograph taken for extracted teeth.

Figure 6.
Sectioning of extracted tooth by a diamond disc from the mesial to the distal side.

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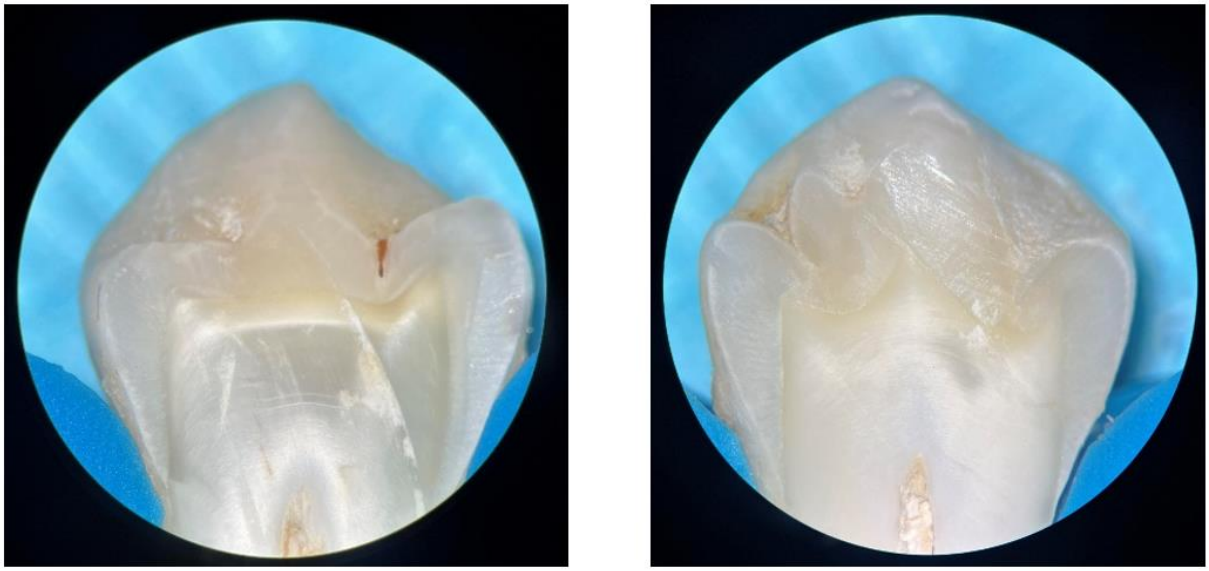

Figure 7.
Examined the extracted teeth under the clinical microscope.

Table 2.
Downer histological examination scores [14].

Downer histological examination scores	
0	No enamel demineralization or a narrow surface zone of opacity
1	Enamel demineralization limited to the outer 50% of the enamel layer
2	Demineralization involving the inner 50% of the enamel, up to the enamel-dentine junction
3	Demineralization involving the outer 50% of the dentine
4	Demineralization involving the inner 50% of the dentine

3. Statistical Analysis

Descriptive statistics (mean, standard deviation, minimum, maximum, median, and interquartile range) were calculated for caries and non-caries teeth. It was compared between PAADI Instructors and AGED Residents using the Mann-Whitney U test. Weighted kappa coefficients were conducted to evaluate interobserver agreement for all three methods (visual, photographic, and histologic examination). Kappa values were calculated using the SPSS statistical software version 23 (SPSS Inc.,Chicago, IL, USA). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for each observer were also calculated. Scores obtained from visual and photographic examinations were compared with histologic examination which was considered the gold standard using the receiver operating characteristic (ROC) analysis to evaluate the observers' ability to differentiate between teeth with and without caries. The areas under the ROC curves (Az values) were calculated using z-tests, with a significance level of (P-value) < 0.05.

4. Result

In the present crossover study, the occlusal surface of the included thirty-four healthy and incipient caries lesions teeth was clinically assessed by calibrated four examiners (two restorative consultants and two Advanced Education in General Dentistry (AEGD) residents). through direct visual examination and indirectly through dental photographic imaging by the International Caries Detection and Assessment System II (ICDAS II) Criteria to detect the non-cavitated stage lesions (incipient pits and fissures caries lesions). The clinical visual examination is performed utilizing a dental mirror, 3.5x dental loupes, and light without the use of a dental explorer to protect the remineralizeable subsurface

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lesions from damage that could result in the unintended conversion of non-cavitated lesions to cavitated lesions. The ICDAS II system utilizes a two-digit coding method for the identification of primary coronal caries. The first digit, ranging from 0 to 9, corresponds to dental restorations; however, this study excluded all teeth with restorations. The second digit, spanning from 0 to 6, is employed to classify caries lesions, as detailed in Table 1 [13]. This systematic coding approach facilitates a structured method for detecting and categorizing dental caries. In this study, concentrates mainly on the incipient pits and fissures caries lesions so, only the scores of 0, 1, and 2 are taken into consideration.

4.1. Visual Clinical Examination Vs Photographic Images Examination

Figure 8 shows the relationship between the clinical observation of 4 examiners using the ICDAS scoring.

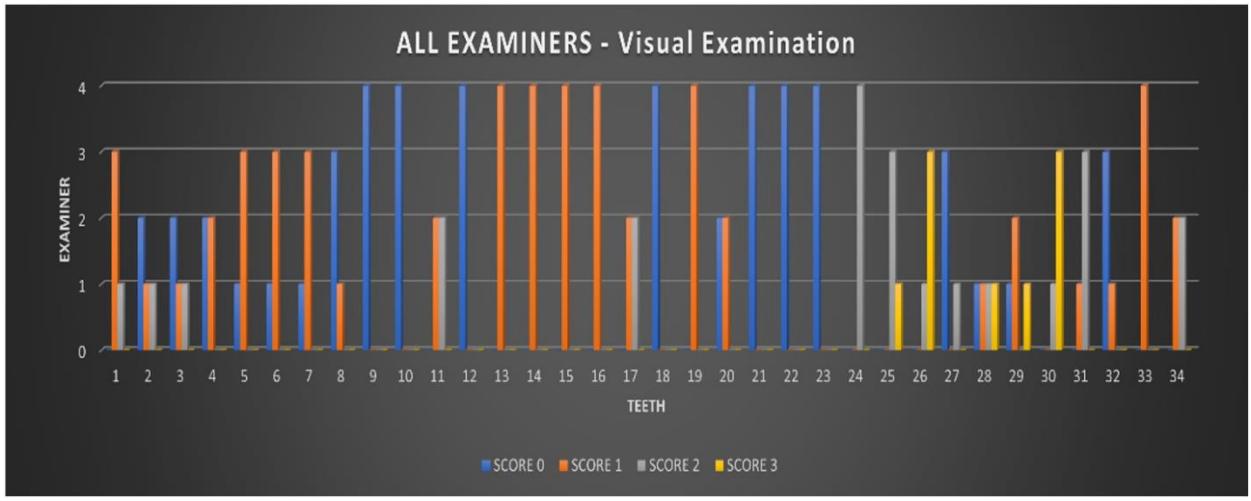

Figure 8.
All Examiners – Visual Examination.

Figure 9 shows the relationship between the photographic examination of clinical cases of 4 examiners using the ICDAS scorin.

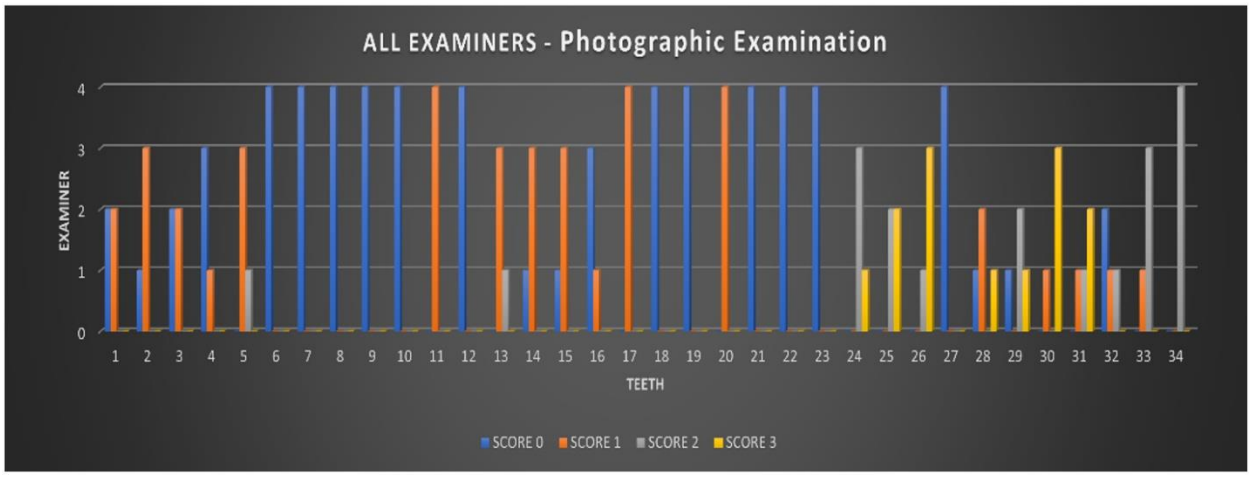

Figure 9.
All Examiners – Photographic Examination.

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One aim of this article is to detect and assess occlusal incipient pit and fissure caries lesions of permanent teeth using professional digital dental photography images and compare them to direct visual examination. As shown in Figures 7 and 8.

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for each examiner is presented in Table 5. Sensitivity and PPV were highest in photographic examination compared with visual in three observers, while specificity and NPV were equal between visual and photographic examination.

Scores obtained from visual and photographic examinations were compared with histologic examination which was considered the gold standard.

Table 3.
Sensitivity, specificity, positive predictive value, negative predictive value, and false-positive ratio for each observer.

	Consultant 1			
	Se(95%CI)	**Sp(95%CI)**	**PPV(95%CI)**	**NPV(95%CI)**
Visual Examination	0.111(0.280-0.483)	0.888(0.518-0.997)	0.500(0.126-0.987)	0.500(0.246-0.754)
Photographic Examination	0.778(0.399-0.972)	0.444(0.137-0.788)	0.583(0.277-0.848)	0.667(0.223-0.957)
	Consultant 2			
	Se	Sp	PPV	NPV
Visual Examination	0.833(0.516-0.979)	0.833(0.359-0.996)	0.909(0.587-0.998)	0.714(0.290-0.963)
Photographic Examination	0.667(0.349-0.901)	0.667(0.223-0.957)	0.800(0.444-0.975)	0.500(0.157-0.843)
	Resident 1			
	Se	Sp	PPV	NPV
Visual Examination	0.643(0.351-0.872)	0.100(0.398-0.100)	0.100(0.664-0.100)	0.444(0.137-0.788)
Photographic Examination	0.643(0.351-0.872)	0.500(0.068-0.932)	0.818(0.482-0.977)	0.286(0.037-0.709)
	Resident 2			
	Se	Sp	PPV	NPV
Visual Examination	0.100(0.753-0.100)	0.00(0.000-0.522)	0.722(0.465-0.903)	0.000 (0.000-0.975)
Photographic Examination	0.769(0.462-0.949)	0.600(0.147-0.947)	0.833(0.516-0.979)	0.500(0.118-0.882)

Source: FPR, false-positive ratio, Se, sensitivity, sp, specificity, PPV, positive predictive value; NPV, negative predictive value, 95 CI, 95% confidence interval.

4.2. Photographic Images Survey

There are repeatedly some disagreements about pit and fissure caries contradictory diagnoses between clinical decisions and presented high contrast dental photography in comprehensive cases presentation in Prince Abdulrahman Advanced Dental Institute (PAADI). All photographs obtained from clinical cases were presented to PAADI residents and PAADI instructors in the presentation room with a large screen then recorded their feedback about pits and fissures conditions either caries or non-caries as shown in Figure 10.

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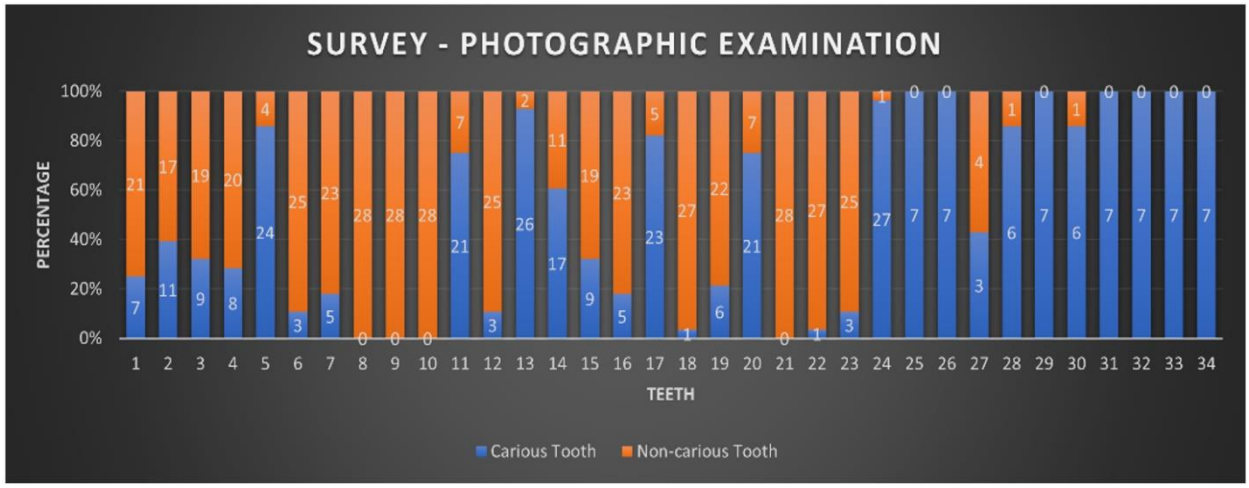

Figure 10.
Survey – Photographic Examination.

Descriptive statistics (mean, standard deviation, minimum, maximum, median, and interquartile range) were calculated for caries and non-caries teeth. It was compared between PAADI Instructors and PAADI Residents using the Mann-Whitney U test. There is a difference in caries and non-caries detection between PAADI Instructors and PAADI Residents Table 3. Residents are more likely to overestimate the results compared with the instructors (P value < 0.05).

Table 4.
Descriptive statistics between PAADI Instructors and AGED Residents.

	PAADI Instructors	PAADI Residents	P value
Carious tooth			0.010*
Mean±SD (Min – Max)	1.58±1.47(0-5)	8.00±8.04(0-22)	
Median (IQR)	1(0.25-3.0)	5.5(0-17.25)	
Non carious tooth			0.001*
Mean±SD (Min – Max)	4.42±1.47(1-6)	14.00±8.04(0-22)	
Median (IQR)	5.0(3-5.25)	16.5(0-22)	

Note: *P value<0.05.

In this study, it was found that the visual clinical examination is better for detecting incipient occlusal pit and fissure caries lesions in permanent teeth. The examiners can check every tooth under various conditions, such as dry and moist conditions, with the aid of dental loupes and light, which is not possible with photographic examination, visual clinical examination is a more accurate and easy procedure. Attempting to make the photographic examination's situation more comparable to a clinical examination by thoroughly clearing the teeth and then capturing the photographic imaging in a dry field and editing it to a 1:1 magnification ratio Therefore, We discovered that using professional equipment, such as DSLR cameras and ring flashes, and properly understanding how to set them up can help you produce high-quality, high-contrast photographs that can be used as a diagnostic tool for detecting incipient occlusal pit and fissure caries lesions.

4.3. Extracted Teeth Examination (Visual Examination Vs Photographic Examination Vs Histological Examination)

In addition to the previously mentioned, we included eighteen extracted teeth that had to be extracted due to orthodontic treatment to see the exact extension of the incipient caries lesions histologically under a clinical microscope at higher magnification based on the downer histological examination which was considered the gold standard. We included extracted teeth only to verify the

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accuracy of the scores of ICDAS II for pits and fissures caries lesions. Figures 11,12 and 13 show the visual, photographic, and histological examinations respectively of all extracted teeth for all examiners.

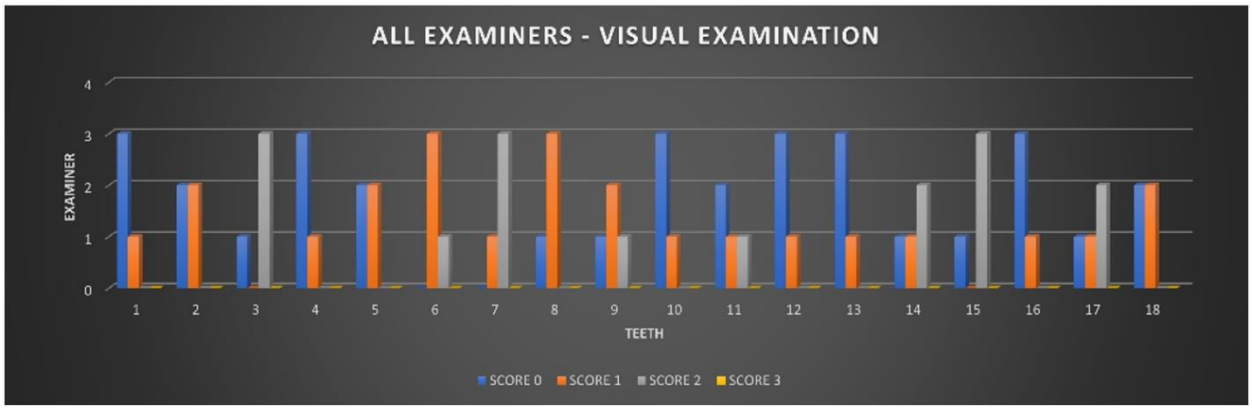

Figure 11.
All Examiners – Visual Examination – Extracted teeth.

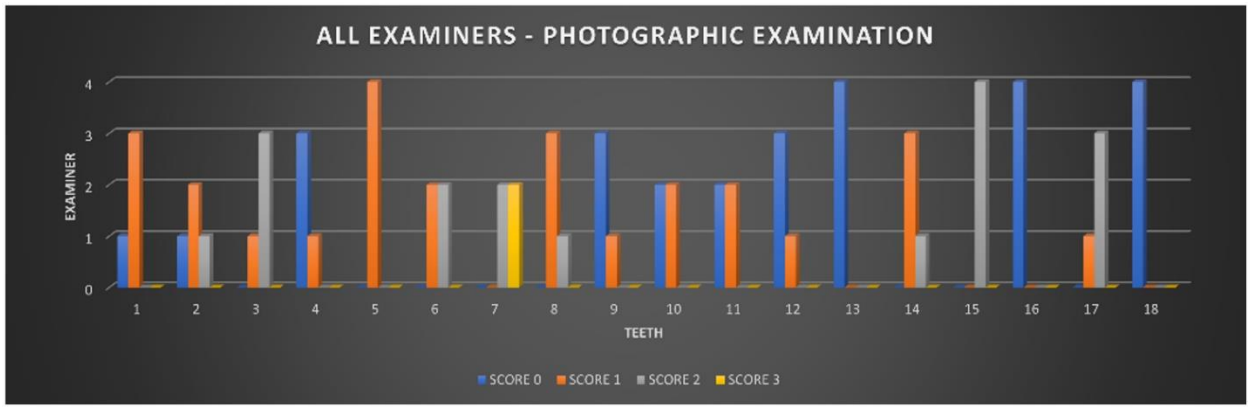

Figure 12.
All Examiners – Photographic Examination – Extracted teeth.

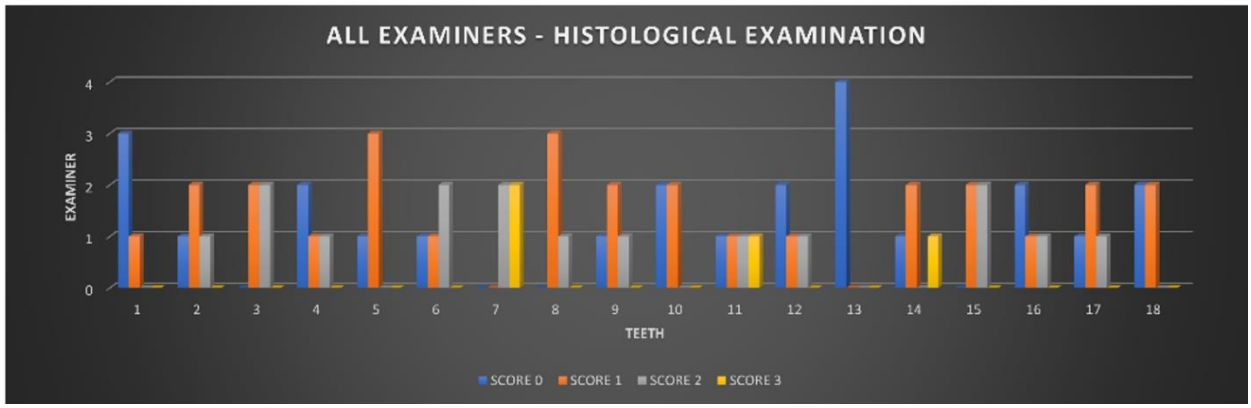

Figure 13.
All Examiners – Histological Examination – Extracted teeth.

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Weighted kappa coefficients were conducted to evaluate interobserver agreement for all three methods (visual, photographic, and histologic examination). Kappa values were calculated using the SPSS statistical software version 23 (SPSS Inc., Chicago, IL, USA).

Table 5.
Inter-observer kappa coefficients among consultants and residents.

	Weighted Kappa-SE			
	Consultant 1-Consultant 2	**Resident 1-Resident 2**	**Consultant 1-Resident 1**	**Consultant 2-Resident 2**
Visual Examination	0.082-0.088	0.115-0.117	0.163-0.121	0.100-0.134
Photographic Examination	0.505-0.162	0.108-0.157	0.522-0.162	0.491-0.171
Histological Examination	0.070-0.181	0.110-0.140	0.061-0.126	0.045-0.151

Source: SE, standard error.

Kappa statistics for inter-observer reliability were calculated. The highest was for the photographic examination (0.108 to 0.522) and the lowest was for the histologic examination (0.045 to 0.110) (Table 4).

Figures 14 show the receiver operating characteristic (ROC) curves for each examiner for each examination method.

Scores obtained from visual and photographic examinations were compared with histologic examination which was considered the gold standard using the receiver operating characteristic (ROC) analysis to evaluate the examiners' ability to differentiate between teeth with and without caries. The areas under the ROC curves (Az values) were calculated using z-tests, with a significance level of 0.05.

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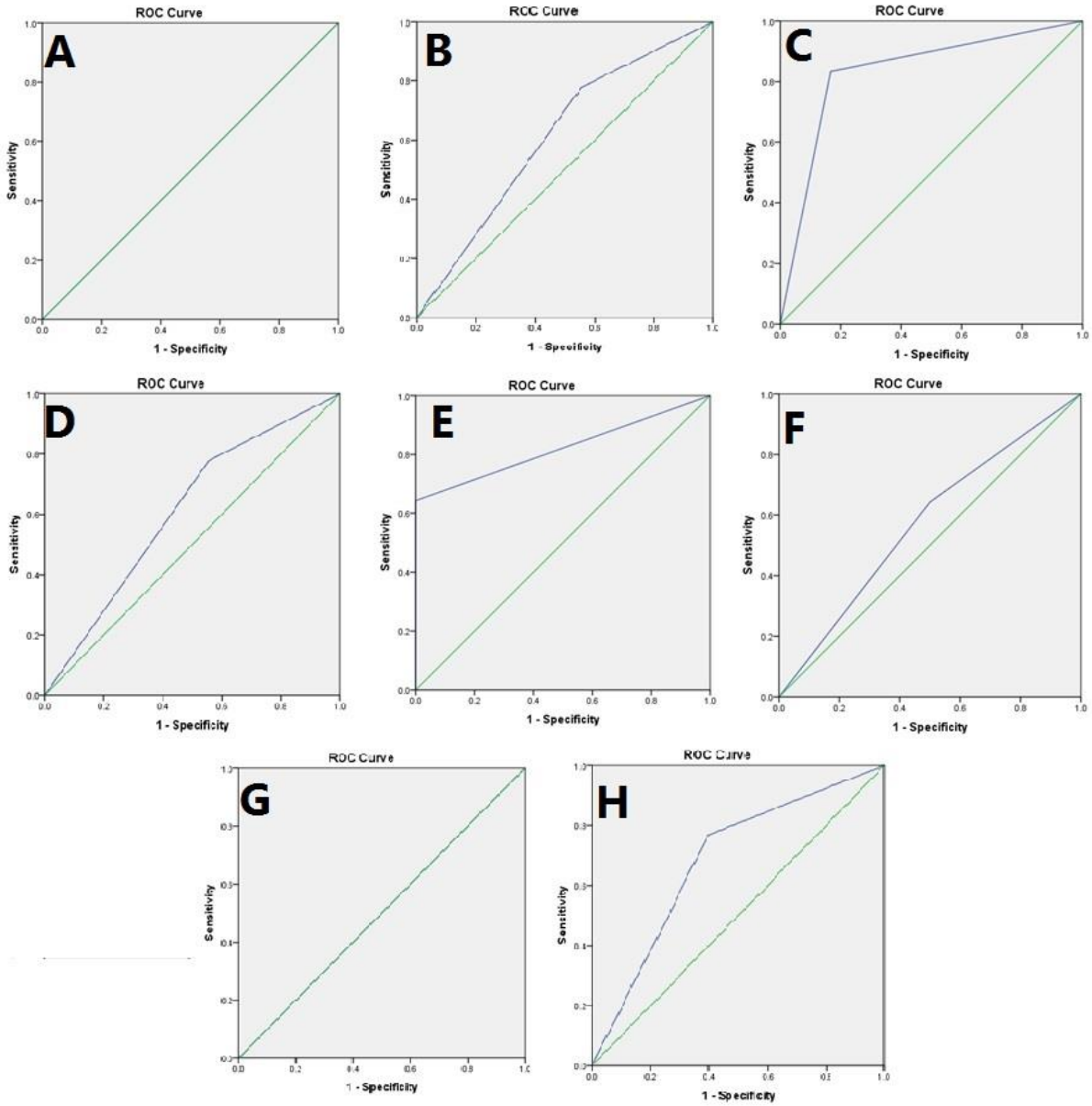

Figure 14.
Receiver operating characteristic (ROC) curves for each observer for each caries examination method.

Consultant 1 A) histology versus visual examination B) histology versus photographic examination, consultant 2 C) histology versus visual examination D) histology versus photographic examination, resident 1 E) histology versus visual examination F) histology versus photographic examination, resident 2 G) histology versus visual examination H) histology versus photographic examination,

The Az values for the different examination methods compared with the gold standard (histologic examination) were calculated and are given in Table 6. The Az values of the two examiners (Consultant 2 and Resident 1) were highest for the visual examination, while it was highest for the photographic examination for consultant 1 and Resident 2.

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Table 6.
Az values, their standard errors, 95% confidence intervals, and significance levels (*P*-value) for each observer.

	Consultant 1	Consultant 2	Resident 1	Resident 2
Visual Examination				
AZ-SE	0.500-0.140	0.833-0.111	0.821-0.099	0.500-0.156
95% CI	0.226-0.774	0.617-1.000	0.628-1.000	0.194-0.806
P value	0.999	0.025*	0.056	1.000
Photographic Examination				
AZ-SE	0.611-0.136	0.667-0.140	0.571-0.168	0.685-0.149
95% CI	0.344-0.878	0.393-0.941	0.242-0.901	0.392-0.977
P value	0.427	0.261	0.671	0.237

Source: Az, an area under the receiver operating characteristic curve; SE, standard error; CIs, confidence intervals.
Note: *$P < 0.05$.

5. Discussion

The International Caries Detection and Assessment System II (ICDAS II) is a valuable tool in the fields of clinical research, clinical practice, and epidemiology. It is designed to detect both cavitated and non-cavitated caries lesions, offering a more comprehensive and early-stage detection compared to other systems. This is in contrast to caries detection systems like the WHO caries detection system, which primarily identifies caries at later stages when lesions are already cavitated. ICDAS II is recognized for its acceptable reliability in identifying caries lesions across different stages of development [13, 15]. The in vitro study aimed to validate the ICDAS-II system for detecting carious lesions by comparing its visual assessment scores with histological findings. The moderate relationship between the ICDAS-II scores and the histological classifications [16] suggests that the ICDAS-II system is reasonably accurate and reproducible for diagnosing occlusal caries. This supports its use in clinical settings as a reliable method for caries detection [14].

Another in vitro study included 690 occlusal surfaces of non-cavitated premolars and molars were inspected by inspectors 1 and 2, prepared within the ICDAS II evaluating criteria. The photos of the occlusal surface and the fluorescence images, which were taken employing a Soprocare (Acetone) intraoral camera, were inspected by inspectors 3 and 4. They concluded that caries location strategy by roundabout visual examination utilizing Soprocare fluorescence camera based on ICDAS II coding displayed a steady and solid level of specificity and a low level of sensitivity. Nonetheless, visual assessment through indirect means demonstrated high accuracy in identifying ICDAS grades 1 and 2 [17]

Dental photography serves several crucial purposes in the field, as outlined in existing research. These include accurately capturing oral cavity conditions, aiding in examinations and diagnoses, assisting with treatment planning, providing legal documentation, facilitating publishing and educational efforts, and enhancing communication among patients, dental professionals, colleagues, and technicians. Additionally, dental photography plays a significant role in marketing. Many studies utilizing dental photography have focused on examining schoolchildren to identify cavities and record developmental enamel defects (DDE) [18-20].

A 2015 systemic review aimed to assess whether photographic examination and subsequent image analysis provided comparable accuracy to visual inspection for diagnosing common dental issues in children and adolescents. The review included sixteen studies that met the specified criteria. Of these, nine studies focused on dental caries, while eight examined enamel defects, with one study addressing both conditions. The review's findings indicated that in three studies, image analysis demonstrated superior performance, while in the remaining six studies, the diagnostic accuracy was found to be comparable to visual inspection [21].

The field of dentistry has witnessed the development of numerous techniques for identifying caries lesions. A comprehensive review and statistical analysis published in 2021 evaluated various caries detection methods, including visual inspection, X-ray imaging, DIAGNOdent 2095, DIAGNOdent Pen, CarieScan Pro, VistaProof fluorescence camera, and SoproLife fluorescence camera. The study's

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findings indicated that visual examination remains the preferred approach for all types of dental surfaces and dentitions, regardless of the specific visual criteria employed [22].

Two systematic reviews and meta-analyses do not incorporate dental photographic imaging as a diagnostic method [22, 23].

The literature has proposed a growing range of techniques for detecting dental caries. This research compares three methods for identifying early-stage caries lesions: a clinical visual examination, a photographic assessment, and a histological analysis. The study aims to evaluate the effectiveness of these distinct approaches in caries detection.

A review of the literature reveals that various technological tools have been employed to capture dental photographic images, including smartphones, intraoral cameras, SLR cameras, and DSLR cameras. The choice of device for obtaining these photos influences the quality of the images and subsequent clinical assessments related to documentation, diagnosis, and treatment planning. It is worth noting that the existing literature does not provide recommendations for specific camera settings considered optimal for taking dental photographs intended for caries detection.

Based on our current understanding, this research stands out as the sole study achieving the necessary image quality for identifying early-stage dental caries using a stationary camera setup. The study employs a single professional DSLR camera (EOS Canon 800D) equipped with a specialized macro lens (f/2.8L Macro 100-mm) and a macro ring flash (YN14EX by YONGNUO). Consequently, the study establishes camera configurations that yield exceptional quality and resolution for dental imaging purposes.

To confirm the accuracy of scoring early dental caries in pits and fissures, we examine extracted teeth visually using ICDAS II criteria (scores 0, 1, and 2). Subsequently, these teeth are cross-sectioned and analyzed microscopically to precisely determine the extent of the initial caries lesions.

Despite the study's merits, the study faces certain constraints. The limited clinical sample size poses a challenge, as finding teeth with early-stage caries lesions is difficult in an area where most dental clinic patients have a high risk of tooth decay. To address this limitation, we have involved several consultants and residents to examine photographic images of clinical cases.

Given the scarcity of research utilizing digital dental photography as a diagnostic method for identifying pit and fissure caries in permanent teeth, there is a pressing need for additional high-quality, well-structured, and standardized studies. These investigations should focus on the detection, diagnosis, evaluation, and ongoing monitoring of occlusal surface caries. It is particularly crucial to emphasize the importance of conducting diagnostic studies, as there is currently a shortage of in vivo trials in this area.

6. Conclusion

A variety of methods for detecting dental caries have been introduced. Nevertheless, this research suggests that visual clinical assessment should continue to be the primary method for identifying early-stage caries in occlusal pits and fissures. The study also demonstrates that digital photography serves as an effective diagnostic approach for recognizing these initial caries lesions in the pits and fissures of occlusal surfaces.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References

[1] K. W. Neuhaus, R. Ellwood, A. Lussi, and N. B. Pitts, "Detection, assessment, diagnosis and monitoring of caries," *Monographs in Oral Science*, vol. 21, pp. 64–75, 2009.

[2] Centers for Disease Control and Prevention (CDC), "Update: Influenza activity—United States, 2004–05 season," *Morbidity and Mortality Weekly Report*, vol. 54, no. 12, pp. 300–304, 2005.

[3] B. A. N. C. f. H. S. U. S. Dye, & National Health and Nutrition Examination Survey (U.S.). , *Trends in oral health status: United States, 1988–1994 and 1999–2004. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention*. Hyattsville, MD, USA: National Center for Health Statistics, 2007.

[4] S. A. Fisher-Owens *et al.*, "Influences on children's oral health: A conceptual model," *Pediatrics*, vol. 120, no. 3, pp. e510-e520, 2007.

[5] D. A. Young and J. D. Featherstone, "Caries management by risk assessment," *Community Dentistry and Oral Epidemiology*, vol. 41, no. 1, pp. e53-e63, 2013.

[6] American Academy of Pediatric Dentistry, *Pediatric dentistry*. Chicago, IL, USA: American Academy of Pediatric Dentistry, 2006.

[7] D. Ricketts, E. Kidd, K. Weerheijm, and H. de Soet, "Hidden caries: What is it? Does it exist? Does it matter?," *International Dental Journal*, vol. 47, no. 5, pp. 259-265, 1997.

[8] N. A. Almosa, T. Lundgren, A. Bresin, D. Birkhed, and H. Kjellberg, "Diagnosing the severity of buccal caries lesions in orthodontic patients at de-bonding using digital photographs," *Acta Odontologica Scandinavica*, vol. 72, no. 6, pp. 474-480, 2014.

[9] I. M. Meurer, L. J. Caffery, N. K. Bradford, and A. C. Smith, "Accuracy of dental images for the diagnosis of dental caries and enamel defects in children and adolescents: A systematic review," *Journal of Telemedicine and Telecare*, vol. 21, no. 8, pp. 449-458, 2015.

[10] R. Amável, R. Cruz-Correia, and J. Frias-Bulhosa, "Remote diagnosis of children dental problems based on non-invasive photographs - A valid proceeding?," in *Studies in Health Technology and Informatics*, *IOS Press*, 2009, pp. 458–462.

[11] U. Boye, T. Walsh, I. A. Pretty, and M. Tickle, "Comparison of photographic and visual assessment of occlusal caries with histology as the reference standard," *BMC Oral Health*, vol. 12, pp. 1-7, 2012. https://doi.org/10.1186/1472-6831-12-10

[12] P. Bottenberg, W. Jacquet, C. Behrens, V. Stachniss, and A. Jablonski-Momeni, "Comparison of occlusal caries detection using the ICDAS criteria on extracted teeth or their photographs," *BMC Oral Health*, vol. 16, pp. 1-8, 2016.

[13] B. Dikmen, "Icdas II criteria (international caries detection and assessment system)," *Journal of Istanbul University Faculty of Dentistry*, vol. 49, no. 3, pp. 63-72, 2015.

[14] A. Jablonski-Momeni, V. Stachniss, D. Ricketts, M. Heinzel-Gutenbrunner, and K. Pieper, "Reproducibility and accuracy of the ICDAS-II for detection of occlusal caries in vitro," *Caries Research*, vol. 42, no. 2, pp. 79-87, 2008.

[15] M. Braga, L. Oliveira, G. Bonini, M. Bönecker, and F. Mendes, "Feasibility of the international caries detection and assessment system (icdas-ii) in epidemiological surveys and comparability with standard world health organization criteria," *Caries research*, vol. 43, no. 4, pp. 245-249, 2009.

[16] K. R. Ekstrand, D. N. Ricketts, and E. A. M. Kidd, "Reproducibility and accuracy of three methods for assessing occlusal caries lesions," *Caries Research*, vol. 31, no. 4, pp. 224–231, 1997.

[17] C. Dhanavel *et al.*, "Evaluation of reliability and validity of occlusal caries detection by direct visual, indirect visual and fluorescence camera using ICDAS II (codes 0, 1, and 2): An in vivo study," *International Journal of Clinical Pediatric Dentistry*, vol. 16, no. 1, pp. 74–78, 2023.

[18] A. Casaglia, P. De Dominicis, L. Arcuri, M. Gargari, and L. Ottria, "Dental photography today. Part 1: Basic concepts," *ORAL & implantology*, vol. 8, no. 4, pp. 122–129, 2016.

[19] A. Golkari, A. Sabokseir, H.-R. Pakshir, M. C. Dean, A. Sheiham, and R. G. Watt, "A comparison of photographic, replication and direct clinical examination methods for detecting developmental defects of enamel," *BMC Oral Health*, vol. 11, pp. 1-7, 2011.

[20] Y. Chen, W. Lee, G. A. Ferretti, R. L. Slayton, and S. Nelson, "Agreement between photographic and clinical examinations in detecting developmental defects of enamel in infants," *Journal of Public Health Dentistry*, vol. 73, no. 3, pp. 204-209, 2013.

[21] M. Inês Meurer, L. J. Caffery, N. K. Bradford, and A. C. Smith, "Accuracy of dental images for the diagnosis of dental caries and enamel defects in children and adolescents: A systematic review," *Journal of Telemedicine and Telecare*, vol. 21, no. 8, pp. 449-458, 2015.

[22] P. Foros, E. Oikonomou, D. Koletsi, and C. Rahiotis, "Detection methods for early caries diagnosis: A systematic review and meta-analysis," *Caries Research*, vol. 55, no. 4, pp. 247-259, 2021.

[23] S. Kapor *et al.*, "Systematic review and meta-analysis of diagnostic methods for occlusal surface caries," *Clinical Oral Investigations*, vol. 25, no. 8, pp. 4801-4815, 2021.

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