The repeatability of three diagnostic methods (visual using ICDAS II, laser fluorescence, and radiographic) for early caries detection

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Abstract. Newly introduced ICDAS II as a visual method, laser fluorescence as another technique that have ability to quantify early mineral loss of tooth structure and intra oral radiograph, are methods can be used in the clinic. To provide standardization for comprehensive caries management at an early stage, all methods supposed to be tested between users. The objective of this research is to evaluate the repeatability of each system. It is a comparative cross sectional study using 100 extracted permanent teeth without obvious cavitation (premolar & molar) that were collected and stored in thymol solution. The teeth were embedded on the wax block and labeled with numbers. All 5 surfaces were examined by 5 examiners using visual (ICDAS II), laser fluorescence (LF) and radiographic examination. The data were then analyzed to measure intra and inter examiner repeatability using Cronbach’s alpha and inter-item correlation matrix. Intra-examiner repeatability for all examiners was >0.7. Chronbach’s α value for inter-examiner repeatability for ICDAS II was >0.8 on 3 surfaces except on buccal and lingual. LF exhibit repeatability of >0.8 on all surfaces. Radiograph shows a low value of inter examiner repeatability (<0.7). Lecturer examiners showed the highest agreement followed by undergraduate students for inter-item correlation while the 2nd and 3rd reading of LF displays the best agreement. ICDAS II score favors more non-invasive treatment compared to LF. ICDAS II showed good repeatability except on buccal and lingual surfaces. In line with some of the previous study, ICDAS II is applicable for caries detection in daily clinical basis. Laser fluorescence exhibits the highest repeatability while the radiograph showed weak inter-examiner repeatability. Treatment decisions of ICDAS II propose more preventive treatment for early caries lesions compared to laser fluorescence.

1. Introduction
Dental caries affect almost all population regardless of their age and races. In most industrialized countries, about 60-90% of school-aged children are assigned [1]. The rates have considerably decreased in the last decade and this could be explained by the improvement in society’s oral hygiene in addition to preventive intervention. However, all of this evidence was measured using diagnostic method when the tooth already cavitated and leads to greater consequences such as loss of teeth, compromising aesthetics, impaired functions and other problems. Therefore, a great consideration of detection and determination of early caries lesion must be prioritized. It is challenging to shift a surgical intervention to be more preventive approaching as a modern concept of caries treatment. To achieve this aim, data collection system must be change worldwide in the system which includes the detection of caries lesion in its early stages.
The manifestation of early caries is chalky white spot appearance on the surface of the tooth. Clinically, this white opaque spot is characterized by being softer than the adjacent sound enamel and is increasingly whiter when dried with air. A cross-section of the white opaque spot reveals that enamel defect with a relatively intact on the surface layer, but damage in subsurface due to acid formed from plaque on the tooth surface [2]. This stage is vulnerable. The weaken tooth surface is easily broken during tooth examination.

Safe and accurate instrument are needed to diagnose early caries. However, it is a very challenging for clinicians to diagnose early caries lesion because even though the tooth surfaces clinically look healthy and intact. It may hide lesions underneath. Since it is not simple, there are several methods that can be used in diagnosing early caries lesion, for example, visual method using ICDAS II as a new system that currently introduce in dental education, clinical practice and research, DIAGNOdent laser fluorescence device that emitted the light to detect early caries and intra-oral radiograph as a common method in detecting caries [3-4]. All the diagnostic method for caries detection in daily clinic should produce a good repeatability in detecting caries. Therefore, the objective of this study was to determine the repeatability of these three diagnostic method (visual ICDAS II, laser fluorescence and radiograph for early caries detection).

2. Materials and Methods
The study was approved by IUM research Committee (IREC 543). Consent patients were obtained prior tooth extraction for their treatment needed. One hundred extracted permanent posterior teeth without restoration or sealants, frank cavitation, hypoplasia, fluorosis or other abnormalities were selected for the study. Calculus and debris were removed from the tooth and then stored in thymol solution at room temperature immediately after extraction. Then, teeth were mounted on wax block and labeled with numbers. Standardized digital periapical (PA) and radiograph were taken for all teeth with a distance of 10 cm from the x-ray tube of the x-ray detector.

ICDAS II examination. Visual examinations were performed by five examiners using the ICDAS codes. All surfaces of each tooth were examined with direct visualization, with the aid of a manual blower and ball-ended probe. Firstly, the assessments were carried out three times, separated by 3 days interval, for assessment of intra-examiner repeatability. Next, after an acceptable intra-repeatability result was achieved, all 5 examiners were required to proceed with inter-examiner repeatability test using the same methods of scoring. The tooth surfaces were scored using the code: 0 (sound), 1 (first visual change in enamel), 2 (distinct visual change in enamel), 3 (localized enamel breakdown), 4 (underlying dentin shadow), 5 (distinct cavity with visible dentin), 6 (extensive cavity with visible dentin) [5].

Laser Fluorescence (DIAGNOdent) examination. Each of the teeth was then examined by using Laser Fluorescent DIAGNOdent pen (KaVo, Biberach,Germany) device. The tip of device is applied on all surfaces of the sample teeth until the device emitted an audio signal and registers a digital reading, which identifies demineralization below the surface of the tooth. Statistical Analysis.

Radiographic Examination. The radiographs were then examined independently by all examiners using a digital x-ray viewer and the score of each site was recorded. The sites were recorded using these scores: 0 (no radiolucency), 1 (radiolucency in outer half of enamel), 2 (radiolucency in inner half of enamel, up to the enamel-dentin junction), 3 (radiolucency in outer half of dentin), 4 (radiolucency in inner half of dentin). Please add some figures according to categorize.

All findings were recorded, inter and intra-examiner repeatability was measured using Cronbach’s alpha and inter-item correlation matrix.

3. Results and Discussion
3.1 Results
A total of 100 posterior teeth were examined. Chronbach’s alpha value for intra-examiner repeatability in each surface mostly reaches ≥0.70 before proceeds with the inter-examiner repeatability scoring. Referring from Table 1, for ICDAS II scoring, 3 surfaces of the tooth which is mesial, distal and
The occlusal shows significantly good to excellence results of Chronbach’s alpha with score varying from 0.83 to 0.91. However, on the buccal surface, the Chronbach’s alpha score is only 0.62 which is questionable while on the lingual shows unacceptable score of 0.16.

**Table 1.** Values of Chronbach’s alpha for intra- and inter-examiner repeatability for 3 diagnostic methods

| Surfaces | ICDAS II | Radiograph | Laser fluorescence* |
|----------|----------|-------------|---------------------|
| Buccal   | 0.62     | 0.52        | 0.89                |
| Lingual  | 0.16     | 0.35        | 0.82                |
| Mesial   | 0.83     | 0.60        | 0.93                |
| Distal   | 0.91     | 0.66        | 0.94                |
| Occlusal | 0.85     | 0.44        | 0.94                |

*intra-examiner repeatability

Dentist as lecturer and an examiner exhibit highest agreement of >0.60 compared to undergraduate students as an examiner as can be seen on **Table 2.** The repeatability for radiograph scoring using Chronbach’s alpha shows questionable results of ≥0.60 on 2 surfaces which are mesial and distal while the other surfaces exhibit poor and unacceptable result ranging from <0.52. For laser fluorescence, all surfaces show significantly good to excellence result of Chronbach’s Alpha varying from 0.82 to 0.94. The second and third readings of interpersonal correlation also shows the highest agreement in all 5 surfaces with score >0.7.

**Table 2.** Inter-item correlation matrix of 3 diagnostic methods

| Surfaces | Methods | (Inter-item correlation matrix) |
|----------|---------|--------------------------------|
| Buccal   | ICDAS II | Radiograph* | LF** |
|          | 1st highest reading | A and C | D and E | 2nd and 3rd |
|          | (0.69) | (0.30) | (0.82) |
|          | 2nd highest reading | D and E | C and E | 1st and 3rd |
|          | (0.53) | (0.30) | (0.74) |
| Lingual  | 1st highest reading | A and D | D and E | 2nd and 3rd |
|          | (0.44) | (0.21) | (0.77) |
|          | 2nd highest reading | B and E | - | 1st and 3rd |
|          | (0.34) | - | (0.60) |
| Mesial   | 1st highest reading | A and C | D and E | 2nd and 3rd |
|          | (0.70) | (0.41) | (0.91) |
|          | 2nd highest reading | D and E | C and D | 1st and 3rd |
|          | (0.67) | (0.37) | (0.78) |
| Distal   | 1st highest reading | A and C | D and E | 2nd and 3rd |
|          | (0.77) | (0.64) | (0.96) |
|          | 2nd highest reading | D and E | C and D | 1st and 2nd |
|          | (0.77) | (0.26) | (0.78) |
| Occlusal | 1st highest reading | A and D | C and E | 2nd and 3rd |
|          | (0.65) | (0.42) | (0.91) |
|          | 2nd highest reading | A and B | C and D | 1st and 3rd |
|          | (0.65) | (0.37) | (0.81) |

**LF:** Laser fluorescence
* involving only 3 examiners
** comparing between readings
According to Table 3, about 97% of the tooth sample from ICDAS II scoring scored 0 to 2, which proposed only preventive treatment for its treatment decision [5] while the other 3% need operative treatment. However, compared to ICDAS II treatment decision for laser fluorescence treatment decision, only 77% of the tooth need preventive treatment while the other 23% need operative treatment.

**Table 3** Percentage scoring of ICDAS II and DIAGNOdent laser fluorescence with treatment decision

| Methods              | Score | Percentage (%) | Treatment needed                |
|----------------------|-------|----------------|---------------------------------|
| ICDAS II             | 0     | 76             | App care                        |
|                      | 1     | 15             | PCA                             |
|                      | 2     | 6              | PCA                             |
|                      | 3     | 2              | PCA / OCA                       |
|                      | 4     | 1              | PCA / OCA                       |
|                      | 5     | 0              | PCA / OCA                       |
|                      | 6     | 0              | PCA / OCA                       |
| Laser Fluorescence   | Healthy tooth substance | 52 | Standard prophylactic measures |
| DIAGNOdent           | Beginning | 25 | Intensive prophylactic measures |
|                      | Strong demineralization | 23 | Minimally invasive treatment |

PCA: Preventive Care Advised
OCA: Operative Care Advised

3.2 Discussion
The Cronbach’s Alpha values for ICDAS II in this study were ranging from 0.62 to 0.91 except on lingual surface. Excluded of lingual, the Cronbach’s Alpha for this study showed higher values than those found by Jablonski-momeni et al. In their study, the values of inter-examiner repeatability were ranging from 0.32 to 0.61 [6]. While Ismail et al. showed almost similar values to this study, which was for inter-examiner repeatability varying from 0.63 to 0.75. The differences among the present investigation and those studies could be explained by the subjective aspects involved in visual examination, such as knowledge and clinical experience of examiners [7-8]. For inter personal correlation; the highest agreement can be seen on distal. While, the lowest agreement is on lingual surface. Generally, dentist as an examiner showed higher mutual agreement than undergraduate student. ICDAS II was presented to serve as a response to the shortcomings of the existing caries detection methods with the ability to visually evaluate the patients’ tooth and restoration conditions. It may be initially presumed that the codes of this system are numerous and challenging, but through a training procedure makes it a logical, efficient and user-friendly system. As most of the clinicians not very familiar with this new method, the ICDAS II should show repeatability before being applied in clinical basis.

Based on the results, laser fluorescence shows good to excellence repeatability in all surfaces. This is supported by the study done by Virajsilp et al. where they found that the reliability of the laser fluorescence is much higher than that of bitewing radiograph for proximal caries detection using primary teeth as a sample [9]. However, this result is contradicted with Bozdemir and others on 2016 where the reliability of laser fluorescence device in their study was lower than that reported in other diagnostic studies with only 0.43 [10]. Hence in this study, it shows that laser fluorescence is the best method among other two methods in term of repeatability. Laser fluorescence has some advantages such as early detection of caries which results in preservation of more dental structure and the use of preventive treatment [11]. Even so, although this is the best method among these three, laser fluorescence showed that it has high sensitivity but low specificity [12] that can lead to the high probability of getting false positive detection. That can further lead to unrequired invasive procedure. So it is recommended to use in combination with other techniques [13]. On top of that, the 2nd and 3rd
readings of interpersonal correlation show the highest agreement in all 5 surfaces and this is probably due to the frequency of usage of the device by the examiner. By the time, the examiner becomes more confident and more precise in using the device after few attempts.

The repeatability of periapical radiograph in this research shows low inter-examiner repeatability in all surfaces. These findings are contrary with the findings of the previous research done by Diniz et al. where they got higher repeatability of bitewing radiograph with 0.74 [7] in their in vitro study of 104 occlusal surfaces of permanent premolars and molars. However, Rodriguez and others found much lesser repeatability even though higher than the current research with 0.50 values [5]. The result in this study indicate that radiograph is not suitable to detect early caries lesion and this is in line with Braga et al. [14], Young and Dutra who reported that intra oral radiograph have poor performance in distinguishing a sound surface from a non-cavitated lesion [14] and can also underestimate the actual depth of the lesion [15]. Besides, bitewing radiograph had been used as the standard method for the detection of proximal dentin decay because it is more sensitive method than clinical inspections and caries can only be detected if it is involving 2-3 mm deep into dentin or one third the buccolingual area [6]. Therefore, in order to increase the repeatability, more training is needed.

Apart from that, ICDAS II scoring favors more preventive measure in early caries lesion in compared with the laser fluorescence as the surfaces needed to undergo operative treatment from the total of 500 surfaces is only 3% whereas for laser fluorescence, about 23% of the surface need to undergo invasive treatment base on their treatment decision according to the ICDAS II Decision Table, and treatment decision from the manufacturer of the DIAGNOdent® laser fluorescence device. Even though DIAGNOdent laser fluorescence shows the highest repeatability in this study followed by ICDAS II and radiographic methods, it cannot stand as sole method in detecting caries lesion as it has some limitation and need to be used with other techniques.

4. Conclusion
ICDAS II showed good repeatability except on buccal and lingual surfaces. In line with some of the previous study, ICDAS II is applicable for caries detection in daily clinical basis. Laser fluorescence exhibits the highest repeatability while the radiograph showed poor inter-examiner repeatability. Treatment decisions of ICDAS II propose more preventive treatment for early caries lesions in compared to laser fluorescence.

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