Original Article

Diagnosing the severity of buccal caries lesions in governmental and private orthodontic patients at debonding, using the ICDAS-II and the DIAGNOdent Pen

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ABSTRACT

Objectives: To clinically evaluate the prevalence of buccal caries and white spot lesions (WSLs) at debonding in governmental and private orthodontic patients, using the International Caries Detection and Assessment System (ICDAS-II) and the DIAGNOdent Pen, and to study the correlation between the two methods.

Materials and Methods: A cross-sectional study was carried out on the nonextracted premolars and anterior teeth of 89 orthodontic patients. They were recruited into two groups based on the treatment center they attended: governmental group (G; n = 45) and private group (P; n = 44). Immediately after debonding, the examination of buccal caries and WSLs on premolars and anterior teeth was carried out using the ICDAS-II and the DIAGNOdent Pen. Cross-tabulation was applied to study the correlation between the ICDAS-II index and the DIAGNOdent Pen by calculating the Spearman correlation coefficient.

Results: The G group showed a significantly higher ($P < .0001$) prevalence of WSLs and/or buccal caries compared to that of the P group based on evaluation by the two methods. Based on ICDAS-II, 43% of the patients in the P group and 9% in the G group were free from any WSLs. In the G group, 22% of the patients had ≥16 lesions, whereas there were none for the P group. The Spearman correlation coefficient between the two methods was .71.

Conclusions: The prevalence of caries and/or WSLs at debonding was significantly higher in the G group compared to the P group. The clinical index (ICDAS-II) showed a good correlation with the DIAGNOdent Pen. (*Angle Orthod.* 0000;00:000–000.)

KEY WORDS: White spot lesions; ICDAS; International Caries Detection and Assessment System; Laser fluorescence; Fixed orthodontic appliance

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INTRODUCTION

Research has shown that fixed orthodontic appliances promote plaque accumulation because of the difficulties patients face in cleaning their teeth. Food retention facilitates white spot lesion (WSL) formation; thus, enamel demineralization on the buccal surfaces has been a common adverse effect of orthodontic treatment.[1,2] Recent studies have reported a high incidence of new WSL development during orthodontic treatment, affecting 60% to 70% of patients.[3,4] Orthodontic patients develop significantly more WSLs than nonorthodontic patients, which leads to esthetic

problems that may develop into caries lesions after orthodontic treatment.[5,6]

Caries are still a problem among teenagers and adolescents in developing countries such as the Kingdom of Saudi Arabia (KSA).[7] Recently, Almosa et al.[8] showed that orthodontic patients treated in governmental centers in KSA had less chance to avoid new cavities compared to patients treated in private centers.

Visual examination to detect caries lesions is the most commonly utilized method because of the ease of its application and the availability of the technique in various clinical and research settings.[9] The International Caries Detection and Assessment System (ICDAS-I) is a visual classification system that was developed in 2003 to allow standardized data collection in relation to caries severity in different settings.[10] Later, the criteria were modified and ICDAS-II, using a seven-point scoring system to describe the pathology and extent of caries lesions, was introduced.[11] The only difference between the two systems is that shadowed lesions from underlying dentin (score 3) and the enamel caries lesions (score 4) in ICDAS-I were switched in ICDAS-II; thus, enamel caries lesions became score 3 and shadowed lesions from underlying dentin became score 4 in the ICDAS-II detection system.[12] The reproducibility, validity, and accuracy of the ICDAS-II have been evaluated by several studies.[12–14] The evolution of caries detection and quantification methods has lead to the development of devices that are able to measure the extent of caries lesions and monitor their progress.[15] The KaVo DIAGNOdent (KaVo, Biberach/Riß, Germany) is a portable laser fluorescence instrument that emits light from a diode laser and that can differentiate between sound and carious tooth tissue.[16] Some studies[17,18] suggested categorizing the readings into categories based on the extent of the caries lesion for easier interpretation. The validity and reproducibility of DIAGNOdent for the detection of caries on different tooth surfaces has been investigated.[17,19,20] The conventional DIAGNOdent and the DIAGNOdent Pen (DP; KaVo) showed excellent agreement in quantification of smooth surface caries.[21]

DIAGNOdent was evaluated for the quantification of WSLs adjacent to fixed orthodontic appliances in vitro, but the findings were not compared to any calibrated, visual examination results.[22] Thus, the aims of the present study were: (1) to clinically study the prevalence of buccal caries lesions, including WSLs, at debonding, using ICDAS II and DP in governmental and private orthodontic clinics and (2) to study the correlation between the two methods for detecting those lesions.

MATERIALS AND METHODS

Study Population and Design

This cross-sectional study comprised 89 patients who presented for debonding after comprehensive orthodontic treatment in both jaws. The patients, identical to those described in a previous study,[8] were consecutively recruited from three governmental and three private orthodontic clinics in Riyadh, KSA. The inclusion criteria were that all patients were (1) free of any diseases or conditions associated with dental caries, (2) free from any active caries lesions before receiving orthodontic treatment, and (3) treated with the same type of buccal fixed orthodontic appliances in both jaws for 1.5–2 years. The study included all nonextracted premolars and anterior teeth (incisors and canines), and the patients were divided into two groups based on the center of treatment: a governmental (G) group (n = 45), with a mean age of 22.5 years, and a private (P) group (n = 44), with a mean age of 21.2 years.

Informed consent was obtained before the start of examination. The College of Dentistry Research Centre Ethical Sub-Committee at King Saud University, Riyadh, Saudi Arabia (Reg. No. NF 2225) approved the study. The prevalence of buccal caries lesions on the G and P groups was determined on the tooth level (qualitative) and on the individual level (quantitative) to evaluate differences between the two groups.

Error of Method

The primary author (Dr Almosa) attended workshops by the manufacturer for training in the correct use of the DP. Two independent examiners examined 20 patients using the two methods to evaluate the interexaminer reliability, and these patients showed at least one WSL. For calibration purposes, the primary author (Dr Almosa) demonstrated and taught the correct use of the DP to the other examiner, and the two examiners then examined the first two patients together before examining the patients independently. To evaluate the intraexaminer reliability, these 20 patients were examined twice by the main author, with a minimum of 2 weeks interval in between.

Clinical Examination

Immediately after debonding and removal of the remaining resin, the teeth were cleaned using a rubber cup, pumice paste, and dental floss, and they were rinsed and dried with compressed air in order to remove plaque and extrinsic stains. Thereafter, all premolars and anterior teeth were examined for buccal caries lesions using the two caries detection methods: the ICDAS-II (Table 1)[23] and the DP. The DP was used

Table 1. International Caries Detection and Assessment System (ICDAS-II) Index

Score	Meaning
0[a]	
0[b]	**Sound tooth surface:** There is no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying). Surfaces with developmental defects such as enamel hypoplasias, fluorosis, tooth wear, and extrinsic or intrinsic stains will be recorded as sound.
1[a]	
1[b]	**First visual change in enamel:** When seen wet, there is no evidence of any change in color attributable to carious activity, but after prolonged air drying, a carious opacity is visible.
2[b]	**Distinct visual change in enamel when viewed wet:** There is a carious opacity or discoloration that is not consistent with the clinical appearance of sound enamel.
2[a]	
3[b]	**Localized enamel breakdown due to caries with no visible dentin:** There is carious loss of surface integrity without visible dentin.
4[b]	**Underlying dark shadow from dentin with or without localized enamel breakdown:** This lesion appears as a shadow of discolored dentin visible through the enamel surface beyond the white or brown spot lesion.
3[a]	
5[b]	**Distinct cavity with visible dentin.** Cavitation in opaque or discolored enamel exposing the dentin beneath. If in doubt, or to confirm the visual assessment, the CPI probe can be used to confirm the presence of a cavity apparently in dentin.
6[b]	**Extensive distinct cavity with visible dentin:** The cavity is both deep and wide, and dentin is clearly visible on the walls and at the base. An extensive cavity involves at least half of a tooth surface or possibly reaching the pulp.

[a] The modified ICDAS-II after merging the seven scores into four scores.
[b] The original ICDAS-II.[11]

according to the instructions provided in the manual from the manufacturer: teeth were rinsed and dried before registration, the DP was calibrated with ceramic standard before each session, the flat tip was swept across the buccal surfaces, and the peak value was considered. Table 2 shows the ranges of values for the DP and their corresponding diagnoses. These values are provided from the manufacturer and are based on the fact that a zero value needs to first be measured on a healthy coronal location. In order to study the prevalence of buccal caries lesions and the correlation between the ICDAS-II and the DP, the ICDAS-II index was merged from seven scores to four scores (Table 1) according to the histological study performed to validate ICDAS-II[12] as follows:

- Score 0 were considered to be healthy, sound tooth and indicated as score 0.
- Scores 1 and 2 were considered to be enamel caries and indicated as score 1.
- Scores 3 and 4 were considered to be deep, enamel caries and indicated as score 2.
- Scores 5 and 6 were considered to be dentin caries and indicated as score 3.

Table 2. DIAGNOdent Pen Values and Corresponding Diagnosis

DIAGNOdent Pen Values	Diagnosis	Score
0–13	Healthy tooth	0
14–20	Enamel caries	1
21–29	Deep enamel caries	2
≥30	Dentin caries	3

Statistical Analysis

All data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS Statistics; version 20; IBM, Chicago, Ill). Descriptive statistics were used to study the mean age, frequency of gender, and different scores of the two methods on the tooth level, and the frequency of buccal caries lesions on an individual level. The independent-sample t-test was applied to the two main groups, G and P, to determine the statistically significant differences of buccal caries lesions on the individual level. Fisher exact test was used to compare the different categories of the buccal caries lesions count on individual levels. For all tests, the significance level was $P < .05$.

The cross-tabulation was applied to evaluate inter- and intraexaminer reliability as well as to study the correlation between the ICDAS-II index and the DP by calculating the weighted kappa and the Spearman correlation coefficient.

RESULTS

The G group comprised 19 males and 26 females, and the P group comprised 14 males and 30 females. There were no statistically significant differences between the two groups in the aspect of age and gender ($P > .05$). The inter- and intraexaminer reliability of the ICDAS-II and the DP for examining buccal caries lesions were evaluated, and kappa values ranged between .87 and .93 (Figure 1). Both methods reveal similar outcomes that show very good reproducibility.
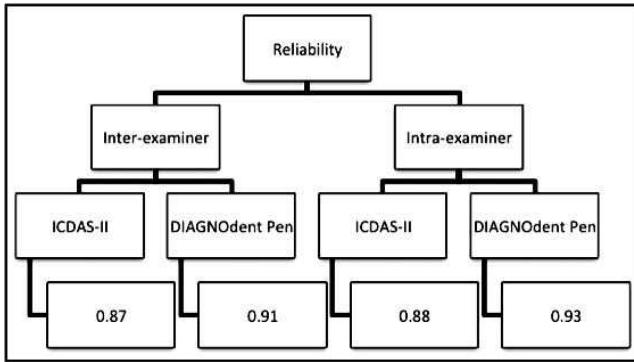
Figure 1. Intra- and interexaminer reliability of the ICDAS-II and the DP.

On Tooth Level

In total, the buccal surfaces of 1653 teeth, 822 teeth in the G group and 831 teeth in the P group, were examined for the presence of buccal caries lesions using two methods: the ICDAS-II and the DP. One hundred twenty-seven teeth were congenitally missing or extracted for orthodontic reasons. Figure 2 illustrates the prevalence, pooled together using the two methods, of buccal caries lesions in the G and P groups. The ICDAS-II and DP indicated that 67.3% and 78.8% of the buccal surfaces, respectively, were healthy. In addition, the ICDAS-II detected scores 1 and 2 (enamel caries and deep enamel caries) almost three times more often than the DP. Moreover, the DP indicated that approximately 10% of the total number of teeth in both groups had dentin caries.

Figures 3 and 4 show the prevalence of buccal caries lesions in the G vs P groups according to the ICDAS-II and DP, respectively. The results reveal higher percentage figures for the DP in comparison with the ICDAS-II for the healthy teeth (score 0) and dentine caries (score 3). Moreover, the percentages of enamel caries, deep enamel caries, and dentin caries (scores 1, 2, and 3, respectively) were higher in the G
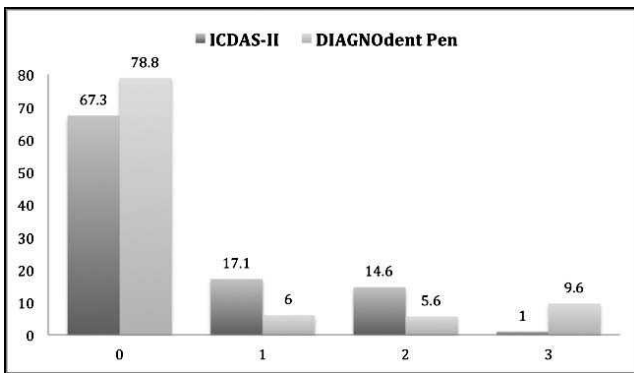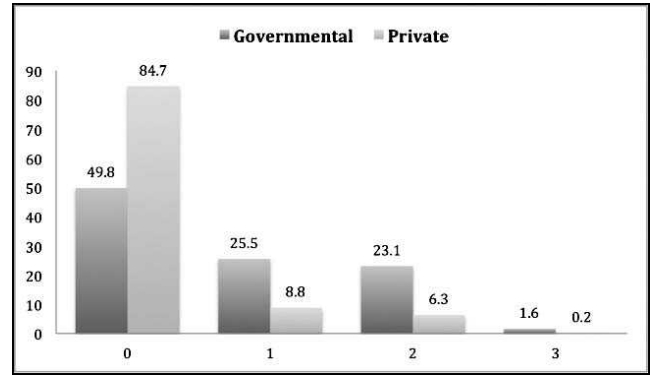

Figure 3. Prevalence (%) of buccal caries lesions using the ICDAS-II in the G vs P groups.

group compared to the P group irrespective of the method used.

On an Individual Level

No statistically significant difference was found between males and females in the aspect of buccal caries lesions ($P > .05$) using either the ICDAS-II or the DP. Statistically significant differences were noted between the G and P groups for buccal caries lesions ($P < .0001$; Figure 5). These differences applied for the total number of lesions as well as after categorizing the lesions into five different counts. In the G group, 8.9% of the patients were free from any lesion, whereas 22.2% had more than 16 lesions. On the other hand, 43.2% of the patients in the P group were free from any lesion; no patients had more than 16 lesions. We also found that the G group had a prevalence for developing six to 20 lesions, whereas the P group had a prevalence for developing up to five lesions.

Correlation Between the Two Methods

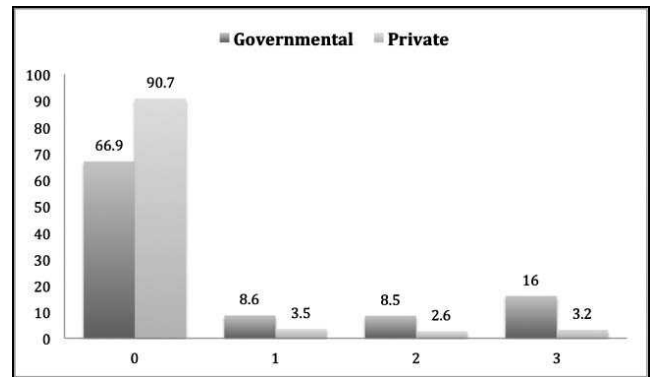To study the correlation between the ICDAS-II and the DP, cross-tabulation was applied (Table 3), from

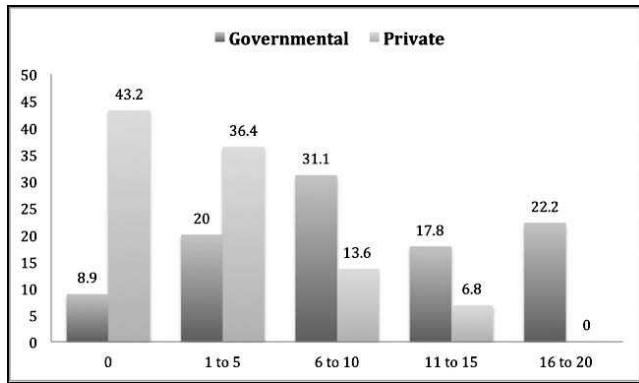**Figure 2.** Prevalence (%) of buccal caries lesions in the G and P groups using the ICDAS-II and the DP.

Figure 4. Prevalence (%) of buccal caries lesions using the DP in the G vs P groups.

Figure 5. Prevalence (%) of patients in the G vs P groups with different numbers of buccal caries lesions.

Table 3. Cross-Tabulation Between the ICDAS-II[a] and the DIAGNOdent Pen

	DIAGNOdent Pen				
Score	0	1	2	3	Total
ICDAS-II					
0	1079	21	9	4	1113
1	191	40	29	23	283
2	32	38	53	120	243
3	0	1	1	12	14
Total	1302	100	92	159	1653

[a] ICDAS-II indicates International Caries Detection and Assessment System.

which the Spearman correlation coefficient was calculated to be .71. Given ICDAS-II with scores of 0 and 3, the chances of getting the same scores using DP were 97% and 86%, respectively. However, diagnosing teeth with scores of 1 and 2 using the ICDAS-II gives a chance of 14% and 22%, respectively, using the DP.

DISCUSSION

This study revealed that the prevalence of buccal caries lesions was significantly higher in the G group compared to that in the P group. This finding was in agreement with a previous report in Australia,[24] which showed that patients who visit private dental clinics receive better dental care compared to those who attend public clinics. Also, the current study supports the results of the earlier caries risk analysis of patients in KSA,[8] which revealed that the G group patients had a greater risk than those in the P group. Differences in socio-economic status and the related differences in oral hygiene practices between the two patient groups may play a role in the variations in the buccal caries lesions prevalence.[25] Since orthodontists in governmental hospitals in KSA are required to see a large number of patients every day, they may not be able to spend sufficient time reviewing preventive dental measures with their patients, and this may have contributed to the increased prevalence in buccal caries lesions during orthodontic treatment. Motivation toward treatment is expected to be greater in patients attending private clinics, because of the accompanied expenses, than it is in those attending free-of-charge governmental institutes, which may also explain the differences in the buccal caries lesions numbers.

In this study, the teeth were rinsed and dried with compressed air in order to remove any paste remnants after being polished with pumice paste, which could cause false-positive readings by the DP.[26] The clinical advantages of using the DP are that it is more objective and the measurements can be displayed to

the patient and may, therefore, have a pedagogical value; however, it is more time consuming clinically, and the device is expensive. On the other hand, ICDAS-II has no cost and is less time consuming clinically, but it's more subjective.

Recent studies[3,4] showed an increased tendency toward development of WSLs following orthodontic treatment. This could be a reflection of the use of advanced methods for the early detection and quantification of carious lesions, or it could be an indication of the ineffectiveness of the prevention programs, especially in the patients treated at the governmental hospitals in KSA. No association between the buccal caries lesions prevalence and gender was revealed in this study. Similar conclusions were reported in previous studies.[5,6] However, a tendency for male patients to develop more WSLs than female patients has been noted in a few studies.[1,4] Ethnic and cultural differences between the studied groups of patients may explain these differences.

The data presented in this study indicate the ICDAS-II and the DP have good inter- and intraexaminer reliability. These findings were in agreement with previous studies.[17,23] The slightly higher reproducibility of the DP could be due to its greater objectivity compared to that of the ICDAS-II. However, according to Landis and Koch,[27] intraexaminer agreement of 61% to 80% denotes significant agreement, whereas exceeding 80% is almost perfect intraexaminer agreement.

The current investigation revealed that the clinical criteria (ICDAS-II) correlated well with the DP. This correlation was measured based on the chance for the DP to be in agreement with the ICDAS-II in the diagnosis of different scores of buccal caries lesions, but not vise versa. For example, 12 out of 14 teeth diagnosed with ICDAS-II score 3 (dentin caries) had the same score using DP, whereas 159 teeth diagnosed with DP score 3 resulted in only 12 teeth having the same score using the ICDAS-II. This could be because the DP tends to give more positive diagnosis with lower specificity, as concluded by

Bamzahim et al.[28] The agreement between the two methods in healthy and dentin caries situations was obviously high and can be justified by the clear differences in diagnosing healthy teeth and teeth with dentin caries clinically.

The reported high prevalence of buccal caries lesions in our study at governmental institutions in KSA indicates the need for establishing a comprehensive approach toward prevention based on the available evidence. The Cochrane review[29] regarding fluoride for the prevention of white spots on teeth during fixed orthodontic appliance treatment concluded there is some evidence that daily fluoride mouth rinse could reduce the occurrence and severity of WSLs.

CONCLUSIONS

- The prevalence of buccal caries lesions at debonding was significantly higher in the G group compared to that of the P group.
- In general, the clinical index (ICDAS-II) shows a good correlation with the laser fluorescence device (DP).

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