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Original Article

Evaluating the performance of led based and lf based devices for the detection of caries under clear and opaque sealants

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Abstract

Aim: The aim of the present investigation was to evaluate the diagnostic ability of laser fluorescence (LF)-based device and a light emitting diode (LED)-based device regarding the effects of different types of fissure sealants and etching modalities under in vitro conditions.

Materials and Methods: All samples (n = 60) were divided into 4 groups. Opaque or clear sealants were applied to the surface of extracted human molar teeth after etching the surface with either acid or laser pretreatment methods. Both the LF-based DIAGNOdent pen device (Kavo, Biberach, Germany) and an LED-based device (Midwest Caries I.D.; Dentsply Professional, York, PA, USA) were used to measure decalcification scores both before and after sealant application and following thermocycling. The Statistical Package for the Social Sciences (SPSS v16.0, IBM, Chicago, IL, USA) was used for statistical analyses. To examine the inter-observer and intra-observer agreements, an intraclass correlation was used. The Wilcoxon test was used to compare the effects of both the sealants and the etching modalities. A p value of < 0.05 was accepted as statistically significant.

Results: Statistically significant higher readings were achieved with the LED device after applying the opaque sealant in both the acid etched (p = 0.006) and laser treated groups (p = 0.001). The clear sealant did not affect the LF- and LED-based devices' readings after etching with either acid or the laser. Thermocycling increased the LF readings in the laser etched/clear sealant group, but it did not change the LED-based device's results.

Conclusion: The LF and LED results were not influenced by etching with either acid or a laser on the clear sealant. After the application of an opaque sealant, higher readings on the LED device were achieved for both the laser treated and acid etched groups. Thermocycling did not affect the LED device's readings.

Keywords: Dental caries; diagnosis; pit and fissure sealants

INTRODUCTION

In the permanent dentition, pit and fissure caries constitute the majority of caries for young children (1, 2). Even with the reduced prevalence of caries in European countries, the overall percentage of occlusal caries has increased (3, 4). The proportion of pit and fissure decay is near 80–90% for permanent posterior teeth and 44% for primary teeth (5). These phenomena become a crucial problem for dental care, especially in developing countries.

In this regard, the use of sealants is recommended as a highly effective evidence-based protective method for dental caries because it prevents the accumulation of plaque and bacteria in the occlusal groove fossa (6). Various materials and techniques that are related to fissure sealants' quality and longevity have been introduced. The different types of fissure sealant agents that are used by clinicians can be categorized according to their polymerization method, viscosity (filled and unfilled), and translucency (opaque and transparent).

In addition to considering the ingredients, a suitable sealant application technique is vital to the prevention of both marginal leakage and microleakage. Microleakage is strongly related to surface roughness and the connection between the fissure sealant and the enamel.

The most widely implemented and known method for roughening enamel surfaces is the use of phosphoric acid (7). The Erbium, Chromium: Yttrium Scandium Gallium Garnet (Er,Cr:YSGG), which has a laser wavelength of 2.78 nm, synchronizes with the absorption peak of water, and is also well absorbed by all biological tissues, including

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enamel and dentin, is one of the most commonly used types of lasers (8). The Er,Cr:YSGG laser is suitable for use in wet conditions. In addition, its water-cooled system does not cause any adverse effects on pulp (9).

Unfortunately, even if all clinical conditions are provided, caries may occur in some cases, which is why it is important to detect caries and plan a treatment procedure as soon as possible.

For this purpose, LF- and LED-based devices can be used to detect caries under restorations. The LF-based device (DIAGNOdent pen) is a tool that helps diagnose carious lesions in occlusal and smooth surfaces by emitting fluorescence after the application of pulsed red light with a wavelength of 655 nm (10). Another optical detection method, the LED-based caries detector (Midwest Caries I.D.), is a detection tool that emits a soft LED between 635 nm and 880 nm (11).

However, the diagnosis of incipient occlusal caries is complicated because of its characteristic image on radiographs as a radiolucent space in the underlying dentin as a sound occlusal fissure surface. Underestimating the detection of these kinds of caries may lead to more serious problems, such as economic loss, excess time, and distress for young children (12). Thus, investigations into new diagnostic technologies and preventive interventions for carious lesions are crucial for future dental health, especially for the young population.

Therefore, the aim of the present *in vitro* investigation was to evaluate the diagnostic ability of LF- and LED-based devices to determine the effects of certain types of fissure sealants and etching modalities.

MATERIAL and METHODS

This study was approved by the Gaziantep University Faculty of Medicine Ethics Committee Presidency (protocol code 382). Before the clinical practice, sample size was determined by a power analysis with 70% power and 95% confidence. A total of 60 permanent human molars, which varied from sound to different grades of carious lesions and which were extracted for orthodontic and periodontal reasons, were included. Teeth with cracks, restorations, cavitations, and developmental anomalies were excluded. The teeth were disinfected with 2% glutaraldehyde and stored in 0.1% thymol solution.

Study Design

All samples were divided into two primary groups by the type of fissure sealants: Group A had opaque sealants (Grandioseal, Voco, Cuxhaven, Germany), and Group B had clear sealants (Controlseal, Voco, Cuxhaven, Germany). Considering the surface pre-treatment methods, the primary study samples were divided into 2 subgroups, and all samples (n = 60) were divided into 4 subgroups of 15 teeth each.

The study procedure was performed as follows. For the laser-pretreated subgroups, the Er,Cr:YSGG laser system (Biolase Technology Inc., San Clemente, CA, USA) was used to irradiate pits and fissures. Before the laser application, the power output was set at 1 W (output parameters: wavelength = 2.78 μm, pulsed with a duration from 140 to 200 μs and a repetition rate of 20 Hz 15% air, 15% water). The laser beam was delivered with a noncontact handpiece and positioned 1 mm above and perpendicular to the fissures. The laser was applied to the cavity's surfaces two times, with an application time of 10 s at intervals of 5 s.

In the adhesives group with the etch and rinse mode, prior to the self-etch mode steps, pits and fissures were etched with 37% phosphoric acid gel for 10 seconds, rinsed with water for 10 seconds, and dried for 5 seconds with an air syringe.

Following the pretreatment procedures of the pits and fissures, sealants were applied per the manufacturer's instructions. A waiting period of 15 s per each application was used for penetration of the sealants, after which they were light-cured for 20 s.

After the sealant applications, the samples were stored in distilled water for 1 day at 37ºC. The specimens were then aged in a thermocycling bath (5,000X at 5°C–55°C; dwell time = 15 s and transfer time = 10 s) to provide thermal stress and thus simulate natural conditions.

Baseline measurements

All the LF- and LED-based device readings were performed before applying fissure sealants and pretreatments. Second measurements were taken after the sealant applications for all the different subgroup pretreatments, and third measurements were taken after the teeth were aged in a thermocycling bath.

LF-based device readings

The LF-based method was performed using a DIAGNOdent pen device (Kavo, Biberach, Germany) with a cylindrical tip after calibration with the ceramic standard. The laser tip was placed vertical to the air-dried occlusal surface of the tooth and rotated along the fissure until the maximum value was obtained. Before each measurement, the laser device was calibrated. The measurements were evaluated according to the cut-off limits presented by Lussi and Helwig (13): D0 (0–13) healthy tooth, D1 (14–20) enamel caries, D2 (21–29) superficial dentin caries, and D3 (≥ 30) deep dentin caries.

LED-based device readings

The LED-based method was performed with a caries ID device (Midwest Caries I.D.; Dentsply Professional, York, PA, USA). The device was used to take measurements after calibration with the ceramic standard. The tip was placed vertical to the occlusal surface, which was moist and free of residue. The emission of a greenish or non-red light (without an audible tone) indicated that the tooth was sound, while the emission of red light (with an audible tone) indicated a decalcificated area or caries. The extent of decalcification was classified into four groups, as assessed according to the cut-off limits presented by the manufacturer's instructions: C0 (no signal/green light) healthy tooth, C1 (slow signal/red light) enamel caries, C2 (medium signal/red light) superficial dentin caries, and C3 (rapid or continuous signal/red light) deep dentin caries.

Two examiners measured the 60 teeth three times with both devices and repeated the procedure one week later to assess the reproducibility.

Statistical analyses

All the values that were recorded with the LF- and LED-based devices were compared, and descriptive statistics were performed using the Statistical Package for the Social Sciences (SPSS v16.0 IBM, Chicago, IL, USA). To examine the inter-observer and intra-observer agreements, an intraclass correlation was used. The Wilcoxon test was used to compare the effects of sealants and etching modalities. A p value of < 0.05 was accepted as statistically significant.

RESULTS

Intra- and inter-observer agreement values for both before and after the sealing procedure are presented in Table 1. The intra-observer agreement ranged between 0.65–0.81, while the inter-observer agreement ranged between 0.67–0.84.

The mean LF pen readings presented a significant increase in the sample that was treated with the laser and sealed with opaque sealant (p = 0.002). In the acid etched/opaque sealant sample, the LF readings were increased significantly after thermal stress was applied (p = 0.001).

Table 1. Presenting intra-inter observers agreements of LED and LF devices in samples which are treated by using laser and acid and applied opque and clear sealants

	Intra-Observer Agreement			Inter-Observer Agreemen		
	O 1	O 2	O 3	O 1	O 2	O 3
Laser - Opeque Sealant						
LED device	0.78	0.81	0.76	0.82	0.77	0.71
LF device	0.69	0.65	0.77	0.71	0.75	0.80
Acid - Opeque Sealant						
LED device	0.79	0.75	0.72	0.76	0.84	0.83
LF device	0.73	0.67	0.70	0.78	0.77	0.80
Laser - Clear Sealant						
LED device	0.80	0.71	0.74	0.80	0.71	0.74
LF device	0.72	0.68	0.73	0.75	0.70	0.79
Acid- Clear Sealant						
LED device	0.77	0.72	0.67	0.77	0.72	0.67
LF device	0.70	0.69	0.73	0.71	0.66	0.77

O1: Before Sealant Application; O2: After Sealant Appliation; O3: After Sealed Teeth Performed Thermal Stress

Table 2. Comparison of p values for all groups

		LF	LED
Groups		p	p
Opaque Sealant with laser treatment	Before - After	0.002*	0.001*
	Before - After thermocycling	0.078	0.001*
	After - After thermocycling	0.348	0.160
Opaque Sealant with acid treatment	Before - After	0.054	0.006*
	Before - After thermocycling	0.001*	0.007*
	After - After thermocycling	0.820	0.157
Clear Sealant with laser treatment	Before - After	0.570	0.102
	Before - After thermocycling	0.139	0.665
	After - After thermocycling	0.044*	0.102
Clear Sealant with acid treatment	Before - After	0.131	0.165
	Before - After thermocycling	0.348	0.144
	After - After thermocycling	0.900	0.516

*** Indicates statistically significant difference at p<0.05**

As introduced by the outcomes of the Wilcoxon test (Table 2), statistically significant higher readings were achieved with the LED device after sealing the teeth with opaque sealant in both the acid etched (p = 0.006) and laser treated groups (p = 0.001).

The clear sealant did not affect the LF- and LED-based devices' readings by etching with either acid or a laser. Thermocycling increased the LF-based device's readings in the laser etched/clear sealant group, but it did not change the LED-based device's results.

DISCUSSION

A considerable rate of lesions appears in the pits and fissures of teeth due to the susceptible anatomy of the occlusal groove fossa. Moreover, most of these intact lesions are caused by demineralization, and in some cases, they affect the entire dentin tubules, even extending to the pulp (9). In a study by Weerheijm et al., carious teeth were evaluated histologically, and it was found that one-third of the carious lesions were formed on teeth with an intact surface and no visual evidence (10). Therefore, it is important to not only prevent carious formations but to detect hidden caries via different diagnostic techniques. In this regard, different types of fissure sealants are used in clinics, and various studies have focused on the clinical performance of this protective method, including its effects on the diagnostic ability of LF and LED-based devices (14-17).

The clear sealant approach is thought to be the best choice because of its transparent nature, which allows professionals to view carious lesions (18). Diniz et al. and Krause et al. stated that applying clear sealants did not cause significant effects on LF measurements (18,19).

Contrary to previous studies, in a study by Bahrololoomi et al. (20), when the LF measurements were performed both before and after sealing the teeth with clear and opaque sealants, the clear sealant significantly increased the LF readings, while the opaque sealant did not affect the measurements. Similar results were found for clear sealants that were applied on primary molars in a study by Asksroglou et al. (17). However, other studies have indicated that applying clear sealants has decreased the readings of the LF-based device (14). In the present investigation, the effects of acid etching and laser etching on the detection devices were also evaluated. In the laser etched group, the clear sealant application increased the mean value of the LF-based device's readings, but this rising value was only significant after the teeth underwent thermal stress. Thermocycling did not affect the LED-based device's readings.

Notably, there are some differences between these two detection devices that warrant consideration. For example, the LF pen emits laser fluorescence, while the LED device emits a soft light. After thermocycling, due to the loss of water on the teeth (through aging), the proportion of absorption and scattering of the irradiation of the LF device may change. Another difference is that the LF-based device presents numeric data, while the LED-based device presents audible and color data, which are interpreted by observers. This means that both devices perform differently. Importantly, the examiner's level of experience, which may affect the results, should be considered..

Per the literature, the results of the studies that have evaluated LF-based devices' measurements for clear sealants have varied widely (14,18,20). This may have resulted from different study designs, different materials being used, and varying levels of caries in the sampled teeth. A study by Bozdemir et al. concluded that an LF-based device might have a different ability to detect carious versus sound teeth, and the level of the caries may also affect the diagnostic ability of an LF-based device (21) .

Regarding opaque sealants, the literature has concluded that opaque agents may absorb and scatter the irradiation and reflected rays, which can cause differences in the LF values (22).

A study by Silverton et al. indicated that LF devices tend to present positive values for sound and carious teeth due to the increasing values that emerge after fissure sealants are applied (23).

Per another study, LF pen readings were found to have decreasing values after the application of opaque sealants (16). The literature also mentions that LF devices have the ability to detect caries after sealing occlusal surfaces with opaque sealants (20). In the present investigation, the LF results were significantly increased by applying laser-treated opaque sealants. However, in the acid etched group, the rank was statistically significant only after thermal stress was introduced. It is known that opaque sealants may have different kinds of filler agents, such as quartz and silica particles, and opacifying agents, such as titanium dioxide. The characteristics of a sealant will differ according to the ingredients and its amount of filler materials regarding scattering or reducing the light that is arriving to the dentin (24). This condition should be considered while interpreting the diverse results of an LF device.

In a study by Aktan et al., the occlusal surfaces of non-restored sound teeth and varying levels of carious teeth were examined via both LF- and LED-based devices; the results suggested that that the LED-based device had more accurate results than the LF-based device did for detecting carious lesions (15). However, in the same study, the LF-based device showed more accurate results for teeth that were free of occlusal caries (15). There are a limited number of studies in the literature on the performance of an LED-based device after using fissure sealants (14). A study by Hastar et al. suggested that the application of a clear sealant did not significantly change the results of the LED-based device; by contrast, after applying the opaque sealant, the readings were significantly increased

(14). Similarly, the present investigation revealed that the clear sealant did not change the LED-based device's measurements after etching with acid and a laser treatment. When considering the opaque sealant, measurements of the LED device were significantly higher for both the acid etched and laser treated groups, which was similar to the results of Hastar et al. (14).

This *in vitro* study revealed that both LF and LED results were not influenced for the clear sealant by etching with both acid and a laser. However, after thermocycling, the laser-etched clear sealant had increased LF readings. Conversely, while the laser-etched opaque sealant had increased LF readings, the acid-etched opaque sealant only had increased readings after thermocycling. After the opaque sealant was applied, higher readings on the LED device were achieved for both the laser treated and acid etched groups. Thermocycling did not affect the LED readings.

CONCLUSION

The present study did have some limitations because it was aimed at identifying potential differences both before and after two different etching modalities on sealants, which were examined by assessing the measurements of LF and LED devices but without consideration for the histological validation. Further in vivo and in vitro studies are needed to investigate the effects of sealants and etching modalities by comparing histological validation. The use of a larger sample and a higher number of observers will exhibit smaller variances and may elicit more accurate results.

Competing interests: The authors declare that they have no competing interest.

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Ethical approval: This study was approved by the Gaziantep University Faculty of Medicine Ethic Committee Presidency (protocol code 382).

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