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Research Article

EFFECT OF Er,Cr:YSGG and Er:YAG LASERs TOOTH PREPARATION ON GAP FORMATION OF BONDED ENAMEL/DENTIN

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A B S T R A C T

Aim: To evaluate the effect of Er,Cr:YSGG and Er:YAG laser irradiations on gap formation at bonding interfaces.
Materials and Methods: Total of 45 standardized class V cavities were prepared on sound premolars with Er,Cr:YSGG laser, Er:YAG laser, or round carbide bur. A two-step self-etch adhesive, with selective enamel acid etching, and a nano-filled resin composite were applied. After 24 hours of water storage at 37°C, samples were subjected to thermocycling artificial aging. gap assessment was performed with a scanning electron microscope (JEOL JSM-6610LV, Japan). Data were analyzed in SPSS software (IBM Inc., Chicago, USA), with a significance threshold of $p<0.05$. Kruskal Wallis non-parametric statistical test was used to compare the mean ranks of the gap formation percentages.
Results: At enamel, both Er:YAG and Er,Cr:YSGG laser irradiation resulted in higher gap formation than the conventional cavity preparation method. Er,Cr:YSGGlaser resulted in the highest gap formation percentage at the dentin-resin interface followed by the conventional method, and Er:YAG laser resulted in the least gap formation.
Conclusion: According to the selected laser parameters, cavity preparation using Er,Cr:YSGG and Er:YAG lasers affects the gap formation at enamel and dentin surfaces. This might be due the morphological and chemical alterations of the irradiated tissues.

INTRODUCTION

The presence of gaps at the bonding interface of resin composite restorations affects the mechanical properties and longevity of restorations [1]. Furthermore, gaps at the tooth-resin interface may result in bacterial penetration, secondary caries, and hypersensitivity of restored teeth [2,3]. Factors such as cavity configuration and preparation, the composition of the adhesive system and restorative material, insertion and curing techniques, or interactions among all these factors can lead to gap formation [4-6].

According to the lasing medium, dental lasers can be classified as gas or solid lasers, and hard and soft tissue lasers [7].Lasers are used in various dental applications, such as caries prevention, cavity preparation, cavity disinfection, and management of hypersensitive teeth [8-11]. The most used dental laser is the erbium laser, which has two distinct types: erbium, chromium-doped: Yttrium, scandium, gallium, and garnet (Er,Cr:YSGG) and erbium-doped: yttrium, aluminum, and garnet (Er:YAG) lasers. Erbium lasers, as compared with other dental lasers, such as carbon dioxide (CO_2) and Neodymium-doped: Yttrium, Aluminum, and Garnet (Nd:YAG) lasers, have the highest affinity for hydroxyapatite and water absorption [7]. Erbium lasers effectively ablate enamel and dentin tissues, owing to an emitted wavelength that matches the absorption peaks of water and hydroxyapatite. When careful, safe, and effective parameters are followed, cavity preparation can be accomplished with minimal negative effects on the pulp [12]. In addition, cavity preparation with erbium lasers provides less noise, pressure, and vibration than the conventional method of cavity preparation (bur preparation)[13]. However, the laser can result in micromorphological and chemical alterations to enamel and dentin surfaces, thereby affecting resin infiltration, the formation of resin tags, and bonding to the irradiated surfaces [14].

Long pulse durations allow more time for the energy to escape from the targeted tissue. Thus, more heat diffuses into the surrounding tissues may negatively affect the ablation efficacy [15]. Er:YAG and Er,Cr:YSGG lasers with different wavelengths (2.78 μm for Er,Cr:YSGG, and 2.94 μm for Er:YAG), pulse energies, pulse durations, and energy densities have been used in studies for cavity preparation. These differences may influence the ablation efficacy of the laser and have varying effects on the gap formation percentages between the restoration and irradiated surfaces [16-19].

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Scanning electron microscopy (SEM) is a reliable modality to quantitatively assess the margins and adaptation of dental restorations. SEM is available in most research laboratories and is less expensive than other assessment methods. Another major advantage of SEM is its ability to provide detailed and clear images with a wide scale of magnifications [5]. However, preparation for SEM analysis is a destructive method that leads to the loss of some parts of the sample during sectioning and preparation, and consequently a loss of information regarding these parts [20].

Although several studies have studied the effects of Er:YAG and Er,Cr:YSGG lasers on irradiated enamel and dentin surfaces, their effects on gap formation at the tooth-resin interface remain unclear. In addition, the interaction of these lasers with newly developed dental materials has not been well studied. This study aimed to compare the effects of Er:YAG (Pluser, Doctor Smile, Via dell'Impresa, Brendola VI, Italy) and Er,Cr:YSGG (Waterlase Millennium™, Biolase Technologies Inc., San Clemente, CA, USA) laser preparations on the gap formation between adhesive resin and enamel and dentin surfaces. Also, to compare cavities prepared with both lasers to the conventional bur-prepared preparations using SEM analysis.

Materials and Method

Tooth selection and preparation

Forty-five sound human premolars extracted for orthodontic or periodontal reasons were collected. Extracted teeth were washed under running water and stored in a container filled with distilled water and 0.05% thymol solution at room temperature for a maximum of 1 week. The teeth were cleaned with a scaler and non-fluoridated pumice with a rubber cup and a slow-speed contra-angle handpiece (W&H DentalwerkBurmoos, Austria). The teeth were visually examined under a SWIFT optical microscope (Tri County Pkwy, Schertz, TX, United States) at 20× magnification to ensure that all teeth were free of caries, decalcification, cracks, abrasion facets, and damage due to extraction. Experimental teeth were stored in another container with distilled water and 0.05% thymol solution at room temperature for a maximum of 1 week until cavity preparation.

Cavity preparation

A total of 45 round non-retentive buccal cervical class V (Cl V) cavities 4 mm in diameter and 2 mm deep were prepared. The cavities were prepared randomly with a round tungsten carbide bur as a control group, Er:YAG laser (Pluser, Doctor Smile, Italy), or Er,Cr:YSGG laser (Waterlase Millennium™, Biolase Technologies Inc., USA) (n=15 each; Figure 1). External margins were placed on the enamel occlusally (2 mm above the cemento-enamel junction [CEJ]) and gingivally 2 mm below the CEJ.

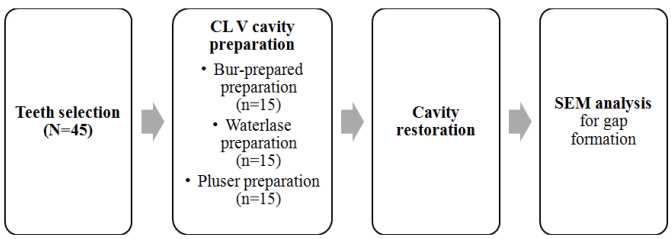

Figure 1 A flowchart of the experimental groups

For cavity standardization, a round hole with a diameter of 4 mm was punched on a plastic strip and attached to the tooth with a piece of utility wax before cavity preparation. The depth of the cavity was verified with a periodontal probe (William's probe).

Samples in the bur-prepared group were prepared under air-water spray coolant with round friction grip tungsten No.7 carbide burs with a head diameter of 2.1 mm (Wave Dental, Worcester, MA, United States). The burs were mounted in a Bien Air high-speed handpiece (Black Pearl, TLC, Bienne, Switzerland) and attached to Planmeca dental unit (Oy, Helsinki, Finland). A new bur was used after every five cavity preparations.

For the Er:YAG laser group (Pluser group), samples were prepared with a Pluser instrument, which emits photons at 2.94 µm with a Pluser tip (600 µm diameter and 8 mm long). Teeth were irradiated with a focused beam of 8.00 Watts (W), at 100% air pressure level, 60% water level, and 20 Hz frequency. Laser parameters were selected as recommended by the manufacturer, thus resulting in satisfactory ablation of the enamel and dentin in a pilot study. The tip was positioned perpendicularly to the tooth surface at 1–2 mm distance. The laser emitted pulses in Pulse SP0 (Gaussian mode) with an average pulse duration of 75 µs, pulse energy of 400 mJ, fluency (energy density) of 142.8 J/cm^2, and irradiance (power density) of 2857 W/cm^2.

Cavities in the Er,Cr:YSGG laser group (Waterlase group) were prepared with a Waterlase Millennium™ instrument, which emits photons at 2.78 µm with an MZ6 sapphire Waterlase tip (600 µm diameter and 9 mm long). The teeth were initially irradiated with the laser parameters recommended by the manufacturer. However, the laser parameters were adjusted for optimal enamel and dentin removal on extracted teeth according to the results of a pilot study. A focused beam of 8.00 W at 70% air pressure level, 90% water level, and a frequency of 20 Hz was used. The tip was positioned perpendicularly to the tooth surface at a 1–2 mm distance. The laser emitted pulses in H mode with 60 µs pulse duration, 600 mJ pulse energy, fluency (energy density) of 214.3 J/cm^2 per pulse, and irradiance (power density) of 2857 W/cm^2. After cavity preparation, all prepared teeth were stored in a container filled with distilled water at 37°C in the dark until the time of restoration, for a maximum of 24 hours.

Adhesive and resin composite material applications

All used materials were listed in table 1. Two-steps Self-Etch adhesive (Clearfil SE Bond 2, Kuraray Noritake Dental Inc., Okayama, Japan) was used with selective enamel etching. Enamel surfaces were acid-etched for 15 seconds with 37.5% phosphoric acid. Etched surfaces were rinsed for 20 seconds or until the etchant was completely removed, then gently dried under an air spray for 5 seconds. Clearfil SE primer was then applied to the prepared surfaces with a light scrubbing motion with a micro-brush for 20 seconds and gently dried for 5 seconds with air. After primer application, Clearfil SE Bond 2 was applied with a micro-brush with a light scrubbing motion for 20 Seconds. Air spray was used to ensure a uniform thickness of the bonding and complete evaporation of the solvent until no movement of the bonding layer was observed. Samples were light-cured for 20 seconds with a high-power Light-emitting diode (LED) light-curing unit (Elipar™ S10 LED, 3M ESPE, St. Paul, MN, USA). The intensity (1200

mW/cm²) of the light-curing unit was verified in every session with a radiometer (Ivoclar Vivadent, Schaan, Liechtenstein).

Table 1 List of materials used in this study

Type	Name (LOT)	Company	Composition
Nano resin composite	Filtek Supreme Ultra, shade A2B (N958713)	3M-ESPE, St. Paul, Min	Bis-GMA, Bis-EMA. UDMA, PEGDMA, TEGDMA, non-agglomerated/non-aggregated 20 nm Silica, and 4-11 nm zirconia fillers, and aggregate zirconia/silica cluster filler (Filler size: 0.6 to 10 µm, filler load: 55.6% by volume; 72.5wt.%)
Two-steps self-etch dental adhesive	Clearfil SE Bond 2 (920220)	Kuraray Noritake Dental Inc., Okayama, Japan	**Primer:** MDP, HEMA, Dimethacrylate monomer, Water, Photoinitiator **Bond:**MDP, HEMA, Dimethacrylate monomer, Microfiller, Photoinitiator
Acid etchant	Gel Etchant (7361843)	Kerr, Orange, CA, USA	37.5% phosphoric acid solution

After adhesive application, a nano resin composite (Filtek Supreme Ultra, body shade A2B) was placed in one increment (2 mm) and light-cured through a Mylar strip 0.05 mm thick with an Elipar™ S10 LED for 40 seconds. Excess materials were gently removed with scalpel blade No.12 (Techno cut, India). To ensure complete polymerization of the materials, samples were stored in distilled water in a Memmert Universal Oven (Memmert GmbH + Co. KG, Schwabach, Germany) set at 37°C for 24 hours. All samples were number coded and subjected to thermocycling artificial aging for 5,000 cycles with an SD Mechatronik thermocycler (SD Mechatronik, Feldkirchen-Westerham, Germany). During thermocycling aging, samples were alternately immersed in distilled water baths at 5°C and 55°C with a dwell time of 20 seconds for each water bath and a transfer time of 10 seconds. All cavities were prepared and restored by the same operator.

SEM analysis and imaging

All teeth were embedded in orthodontic acrylic resin and sectioned in the mesiodistal direction, and parallel to the tooth long axis, into three sections (mesial, middle, and distal). A circular disc blade with a thickness of 0.2 mm was used for samples sectioning at low speed (Isomet 1000 Linear Precision Saw, Buehler, Lake Buff, Illinois, USA). Sectioned pieces were mounted into 6 cm cylindrical molds with epoxy resin, then polished under water cooling with a Leco GPX 300 instrument at 75 rpm speed with an ascending series of silicon carbide papers (400, 600, 1200, and 2000 grit) for approximately 1 minute per grit. Next, the samples were subjected to ultrasonic cleaning for 5 minutes to remove debris.

The samples were then soaked in 35% orthophosphoric acid for 15 seconds and cleansed under running water. Subsequently, they were immersed in 5% sodium hypochlorite solution (NaOCl) for 30 minutes and rinsed under running water. All samples were then dehydrated in a graded ethanol series (70%, 80%, and 96%) in ascending order for 1 hour each.

After being air-dried for 5–10 seconds, samples were placed in the sample stage of a sputter coating machine (Quorum, Q150R ES, UK), which deposited a thin film (10 nm) of gold for 1 minute running time. All samples were loaded into a JEOL JSM-6610LV scanning electron microscope (JEOL, Tokyo, Japan) for image processing and analysis. Two magnifications were used for sample analysis: 100× to have an overview of the sample, and 400× to measure gaps at bonding interfaces.

The mean gap formation percentages were calculated along the tooth-resin interfaces on enamel and dentin surfaces with the following equation: [(P/L) × 100], where P is the Interfacial gap length at enamel (or dentin), and L is the total length of prepared enamel (or dentin) walls. Sample preparation for SEM analysis was performed by a single operator blinded to the coding system.

Statistical analysis

Data were analyzed in SPSS 26.0 version statistical software (IBM Inc., Chicago, USA). Descriptive statistics (mean, standard deviation, median, and interquartile range) was used to describe the quantitative outcome variable (interfacial gap percentage) values. Because of high standard deviations in the gap percentage values (Table 4.2), Kruskal Wallis non-parametric statistical test was used to compare the mean ranks of the gap formation percentages among the six combinations of three cavity preparation methods (bur, Waterlase, and Pluser) and two surfaces (enamel and dentin). A p-value ≤ 0.05 was considered to indicate statistical significance of the results.

RESULTS

Means and standard deviation values are shown in Table 2. Medians, interquartile range values, and mean ranks are shown in Table 3. The comparison of the mean ranks of the gap formation percentages among the six combinations of two surfaces and three preparation methods showed highly statistically significant differences ($p<0.0001$).

The mean ranks of gap formation at the enamel-resin interface were significantly lower than those at the dentin-resin interface regardless of the preparation method. Hence, it was assumed that tissue type (enamel and dentin) has a significant effect on the gap formation percentage when different preparation methods are used.

Table 2 Descriptive statistics [mean ± standard deviation (Sd.)] of interfacial gap (%) among the three cavity preparation methods in each of the two surfaces

Type of surface and preparation methods	Interfacial gap % [Mean ± (Sd.)]
Enamel + Bur	0.00(0.00)
Enamel + Waterlase	0.538(2.08)
Enamel + Pluser	0.231(0.89)
Dentin + Bur	1.803(3.67)
Dentin + Waterlase	2.558(4.98)
Dentin + Pluser	1.936(5.00)

Table 3 Comparison of mean ranks of interfacial gap (%) among the three cavity preparation methods in each of the two surfaces

Type of surface and preparation methods	Interfacial Gap % Median (IQR)	Mean Ranks	p-value
Enamel + Bur [a]	0.00(0.00)	32.50	
Enamel + Pluser [b]	0.00(0.00)	35.80	
Enamel + Waterlase [b]	0.00(0.00)	36.13	
Dentin + Pluser [c]	1.34(2.47)	50.23	<0.0001
Dentin + Bur [d]	0.366(1.79)	55.97	
Dentin + Waterlase [e]	0.00(1.25)	62.37	

Different letters indicate significant differences between groups ($p<0.05$)

Enamel surfaces with bur preparation had significantly lower gap formation percentages than the other preparation methods (Pluser [Er:YAG] and Waterlase [Er,Cr:YSGG]). No significant difference was observed in the mean ranks of the gap formation percentages at enamel surfaces prepared with both lasers. In contrast, at dentin surfaces prepared with the Pluser laser, the gap percentage values were significantly lower than those prepared with the other two methods (bur and Waterlase). The gap formation percentage at dentin surfaces prepared with the Waterlase laser were significantly higher than those prepared with the bur and Pluser laser.

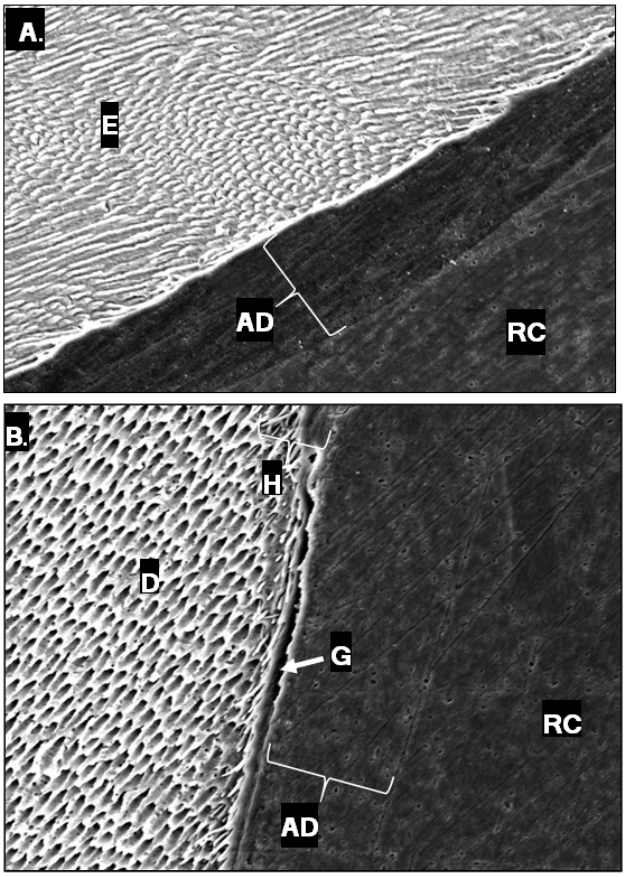

Figure 2 SEM respective images of enamel (A) and dentin (B) surfaces prepared using bur with a magnification of x400
G: gaps, E: enamel, D: dentin, RC: resin composite, AD: adhesive layer, and H: hybrid layer

SEM indicated that bur-prepared enamel appeared smoother than laser-prepared enamel. In addition, constant thickness of the adhesive and hybrid layers was observed at the bur-prepared dentin-resin interface (Figure 2A). Both laser-prepared groups showed rough enamel surfaces with microcracks. The Waterlase-prepared enamel showed greater surface roughness (Figure 3A), whereas the Pluser-prepared enamel showed more microcrack formation (Figure 4A). Resin macro-tags were easily seen where the resin filled the spaces created by the rough laser-prepared enamel surfaces, particularly in Waterlase-prepared enamel (Figure 3A).

In the bur-prepared group, compared with the laser-prepared groups, a smooth dentin surface with a constant thickness of the adhesive layer, and a thinner and more homogeneous hybrid layer were observed (Figure 2B). Uniform resin tags with tiny lateral extensions were also observed in bur-prepared dentin (Figure 5A).

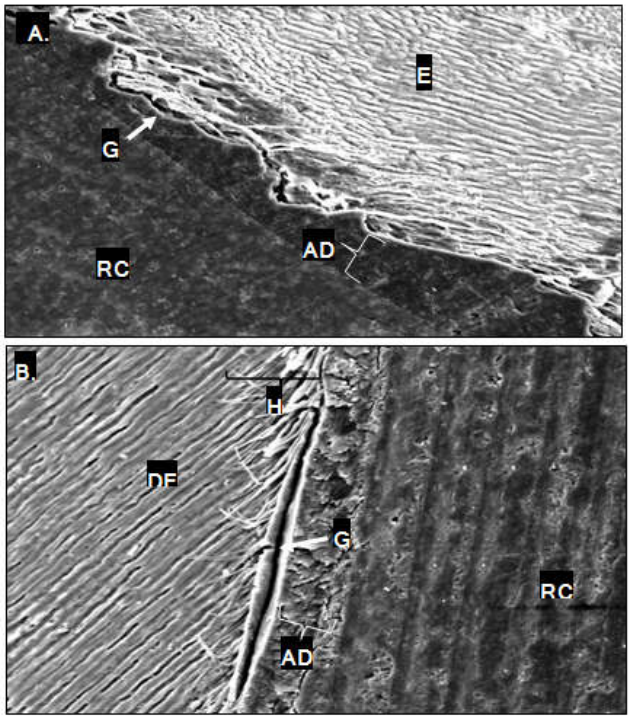

Figure 3 SEM respective images of enamel (A) and dentin (B) surfaces prepared using Waterlase (Er,Cr:YSGG) laser with a magnification of x400
G: gaps, E: enamel, DF: Dentin fusion, RC: resin composite, AD: adhesive layer, and H: hybrid layer

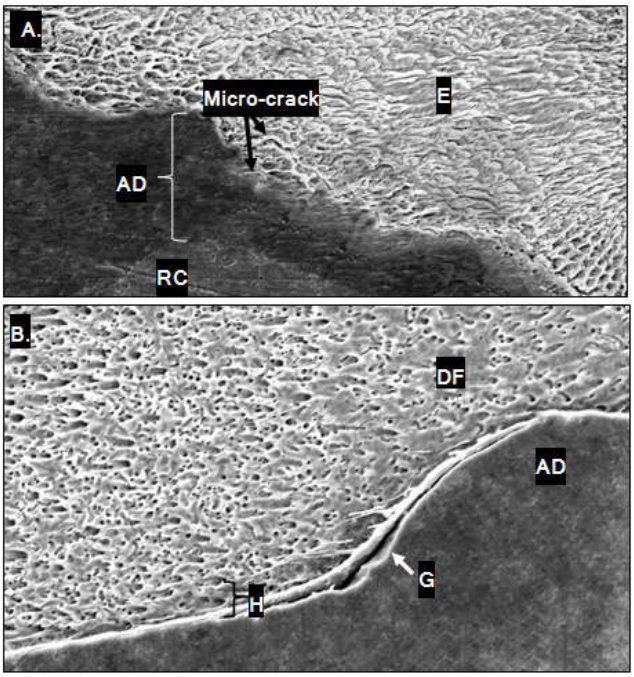

Figure 4 SEM respective images of enamel (A) and dentin (B) surfaces prepared using Pluser (Er:YAG) laser with a magnification of x400
G: gaps, E: enamel, DF: dentin fusion, RC: resin composite, AD: adhesive layer, H: hybrid layer

Dentin fusion was easily observed in both laser-irradiated groups (Figures 3B and 4B). Adhesive layers with diverse thicknesses were observed in laser-prepared groups at the dentin-resin interface (Figures 3B and 4B) however, they were more clear in Waterlase-prepared dentin. Longer resin tags with clear lateral extensions were also seen in both laser-prepared groups (Figures 5 B and C), in contrast to the bur-prepared dentin (Figure 5A). The Waterlase-prepared dentin showed longer resin tags with more prominent lateral extensions than the Pluser-prepared dentin.

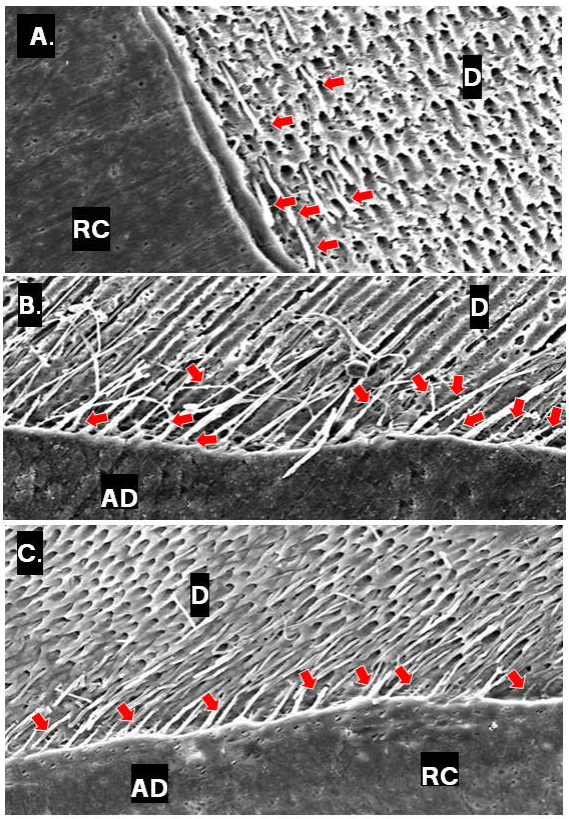

Figure 5 SEM respective images of resin tags with lateral extensions (red arrows) at dentin surfaces prepared using (A) bur, (B) Waterlase laser, and (C) Pluser laser with a magnification of x400
G: gaps, E: enamel, D: dentin, RC: resin composite, AD: adhesive layer, and H: hybrid layer

DISCUSSION

Based on the selected laser parameters, the results indicated that a conventional method (carbide bur) for cavity preparation resulted in smoother enamel surfaces and significantly lower gap formation percentages at enamel-resin interfaces than both laser methods. In contrast, Tekce*et al*. have reported that the cavity preparation method (diamond bur or Er:YAG laser) does not affect gap formation at the enamel-resin interface [9]. This difference in findings might have resulted from the use of different laser parameters, dental adhesives, and bur types (diamond bur) in their study. Tekce*et al.*[9] have used a Single Bond Universal adhesive (3M ESPE) with ultra-mild acidity (pH < 2) in self-etch application mode. In contrast, in the current study, enamel selective pre-etching was performed with strong acid for all groups before the application of two-step self-etch adhesive with mild acidity (pH of 2). The application of self-etch adhesives with mild or ultra-mild acidity to enamel results in low micromechanical interlocking and low chemical reactivity of the adhesive to the calcium in enamel. This effect can be compensated by selective pre-etching of the enamel [21].

Laser-irradiated enamel surfaces showed irregular surfaces, whereas the enamel prepared with a bur showed smoother surfaces. These observations were consistent with the findings of previous studies indicating an irregular smear layer-free of irradiated enamel [22,23].Earlier studies have reported that enamel irradiation with an erbium laser results in morphological and chemical changes including zones of melting, crystallization, and microcracks [22,24]. In addition, previous studies have found higher ions of calcium (Ca) and phosphate (P) ions after the enamel irradiation as a result of evaporation of the organic compounds [25,26]. In addition, Lombardo *et al.*, in 2019, reported an increase in acid resistance of irradiated enamel [27].These alterations in mineral content may affect the interaction of Methacryloyloxydecyl dihydrogen phosphate(MPD) containing adhesives with irradiated enamel surfaces. MPD-containing adhesives resulting in partial demineralization of tooth surface and subsequent chemical bonding to Ca and P, according to the adhesion/decalcification concept [25,26]. This mechanism may explain why the traditional enamel bur preparation resulted in a lower gap formation percentage than the laser-prepared enamel.

In the present study, Pluser and Waterlase lasers devices were used at different wavelengths, pulse durations, pulse energies, and fluencies, thus resulting in distinct consequences on the irradiated surfaces [17]. The Pluser (Er:YAG) laser penetrates approximately 7 µm into the enamel and 5 µm into the dentin, whereas the Waterlase (Er,Cr:YSGG) laser has three times the penetration depth of the Er:YAG laser [19]. However, the current results showed no significantly different effects of Waterlase and Pluser laser irradiation on the gap formation percentage at the enamel-resin interface. This finding may be attributable to the selected laser parameters with copious water-cooling during enamel irradiation, and the dental adhesive used. Adequate water-cooling during enamel irradiation has been found to minimize the negative effects of the erbium laser [22,24]. In dentin, similarly to enamel, earlier studies have reported typical micromorphological features of the erbium laser-irradiated surfaces. Irradiated dentin shows rough irregular smear layer-free surfaces with protruded open peritubular dentin. Fusion and melting of the collagen fibrils, surfaces with micro-cracks, and fissures have also been reported [17,28,29]. Dentin laser irradiation also results in thermal denaturation and shrinkage of the collagen, owing to the breakage hydrogen bonds and the three-polypeptide chains in the triple helical molecular structure [17].

The results of the current study showed resin tag formation with lateral extensions and hybrid layers among all tested groups. However, these features were more prominent in the laser-prepared groups than the bur-prepared group. The production of longer resin tags with lateral extension might have been due to resin penetration into the microcracks that formed on the laser-prepared dentin. These observations are in agreement with findings from previous studies reporting longer resin tags with lateral extension in erbium laser-prepared dentin [16,30].

The negative effect of the erbium laser on the irradiated dentin could be minimized through the selection of proper laser parameters with shorter pulse duration and lower fluency, thus resulting in less energy transferred into heat and consequently less thermomechanical damage to the irradiated tissue. Trevelin *et al.* have concluded that longer pulse durations (300 and 600 µs, compared with 50 µs) results in a thicker altered dentin layer [17]. In the current study, the Waterlase (Er,Cr:YSGG) group showed the highest gap formation percentage at the dentin-resin interface among the three tested preparation methods, possibly because the Er,Cr:YSGG laser penetrates deeper into dentin than the Er:YAG laser. Consequently, more collagen alterations might have formed in Waterlase-prepared dentin and subsequently impaired resin infiltration into the prepared dentin [15,22,24].

Several studies have reported higher acid resistance of erbium laser-irradiated dentin [31,32], thereby affecting resin infiltration and hybridization [28]. Ayar *et al.* have reported incomplete infiltration of the resin within the laser-irradiated dentin, an effect attributed to morphological alterations [33]. In contrast, in this study, resin infiltration with lateral extensions was observed in all tested groups and was more pronounced in both lasers-irradiated groups. This finding may attribute to the use of two-step self-etch (Clearfil SE Bond 2) bonding with mild acidity (pH of 2) and the resultant smear layer-free dentin in the laser-irradiated groups.

A previous study has reported that using carbide burs for dentin preparation results in a thin, loosely organized smear layer that is easily dissolved with a mild acidic agent [34]. However, the results of the current study showed higher gap formation percentages at the dentin-resin interface in the bur-prepared group than the Pluser group. This finding might be explained by the presence of a modified smear layer within the hybrid layer that was not rinsed off in bur prepared dentin[35].
The current results showed higher gap formation percentages at dentin-resin interfaces than enamel-resin interfacesregardless of cavity preparation methods (bur, Pluser, and Waterlase) used. This finding might have been due to the higher water content of dentin than enamel. In addition, unlike enamel tissue, dentin tissue is less mineralized and lacks homogeneity, thus potentially affecting gap formation at dentin-resin interfaces [15]. Another possible reason for the lower gap formation percentage at the enamel-resin interface might be due to the use of enamel selective acid pre-etching before the application of the Clearfil SE primer. Higher sealing ability of self-etch adhesive when enamel selective pre-etching is performed has been reported [36].

Using one two-step self-etch adhesive (Clearfil SE Bond 2) and one setting parameter of Er:YAG (Pluser) and Er,Cr:YSGG (Waterlase) are limitations of the current study. In addition, the use of natural extracted teeth with variable mineral content might have resulted in variations in the outcomes. In addition, the shortage of gap formation studies on erbium laser-irradiated cavities with detailed descriptions of the laser setting parameters hinders the comparison of study results. Further studies are needed to evaluate gap formation at the tooth-resin interfaces of cavities prepared with Er,Cr:YSGG, and Er:YAG lasers with different laser setting parameters, different tip lengths and diameters, and different bonding agent types.

CONCLUSION

According to the parameters of the selected lasers, it could be concluded that:

- Conventional bur cavity preparation resulted in a lower gap formation percentage than observed on Er:YAG and Er,Cr:YSGG laser-prepared enamel surfaces, when two-step self-etch adhesive in conjunction with enamel selective etching was used.
- At the dentin-resin interface, Er,Cr:YSGG cavity preparation resulted in the highest gap formation percentage, followed by bur and Er:YAG preparations, when two-step self-etch adhesive was used.

Clinical Relevance

Cavity preparation with erbium lasers results in morphological and chemical alterations in both enamel and dentin. These changes may affect the adhesion of resin restorations to irradiated tooth surfaces.

Data Availability

The article includes all data that supports the conclusions of this in vitro investigation.

Conflict of Interest

There are no conflicts of interest declared by the authors.

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Declarations of Interest

None.

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