Original Article

Assessment of Tooth Preparation via Er: YAG Laser and Bur on Microleakage of Dentin Adhesives

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Abstract
Objective: Microleakage can be responsible for tooth hypersensitivity, secondary caries, and the possibility of pathological pulp alterations in restored teeth.Recently, alternative methods for tooth preparation such as laser irradiation have been studied; but there are limited studies on primary teeth. The aim of this in vitro study was to compare the degree of microleakage of composite restorations prepared by Er:YAG laser and conventional bur preparation with two adhesive systems in primary teeth.
Materials and Methods: Eighty primary canine teeth were randomly divided into 4 groups. Class V cavities were prepared by Er:YAG laser or diamond bur on buccal surface. The groups were as follows: group1: High speed drill + self-etching adhesive Adper Prompt-L-Pop, group 2: Er:YAG laser + etch & rinse adhesive Adper Single Bond, group 3: High speed drill + Adper Single Bond, group 4: Er:YAG laser + Adper Prompt-L-Pop. Cavities were restored with Filtek Z250 composite resin. Then all of the specimens were polished, thermocycled, immersed in 2% methylene blue solution and sectioned longitudinally. Degree of microleakage was evaluated by two evaluators who assigned the micrleakage score (0 to 3). The original data were analyzed by the Kruskal-Wallis and Dunn's tests.
Results: There were significant differences between bur-prepared cavities in the Adper Single Bond and other groups. There were no statistically significant differences between other groups.
Conclusion: Laser-prepared cavities showed higher microleakage scores than cavities prepared with diamond bur with etch and rinse adhesive system. No significant difference was revealed between the laser and bur-prepared cavities using self-etch primers.
Key words: Microleakage; Er:YAG laser; Etch and rinse adhesive; Self-etch adhesive; Bur

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INTRODUCTION

Laser technology is now widely used in pediatric dentistry due to better compliance of children [1]. It can be used in diagnostic, preventive, restorative, and endodontic dentistry.CO2 and Nd:YAG (neodymium-doped yttrium aluminum garnet) lasers were the first types of lasers assessed for their effect on dental hard tissues [2-4]. These kinds of lasers did not show sufficient capability for removal of dental hard tissues [5-7]. The Er:YAG (Erbium: yttrium-aluminum-garnet) laser was introduced in 1974 by Zharikov with a wavelength of 2940 nm [8]. This type of laser is absorbed by water molecules more than other types [9-12]. Hibst and Keller used Er:YAG laser for cutting dentin, enamel and carious tissue and Kayano reported that it can be used for cavity preparation [8].

Lasers have some advantages such as low vibration and noise during cavity preparation and little or no need for local anesthesia compared to conventional handpiece. Laser is a promising means for removing dental tissue with water evaporation; which is unique for mineralized tissue. The first mechanism of action of Er:YAG laser on hard tissue is thermal effect on water molecules. The absorbed energy then leads to superheating and evaporation. Increased vapor pressure leads to micro-explosive expansion of the tissue and the tissue is separated [13, 14]. Some characteristics of laser-treated dental tissue include coarse microscopic surfaces without demineralization, open dentinal tubules without formation of smear layer, and dentin surface sterilization [15, 16].

Laser treatment leads to such physical changes as melting and recrystallization with frequent pores, which creates a coarse surface that provides micromechanical bond for adhesives [17]. Microleakage leads to secondary caries and pulpal pathologic changes after restoration; thus, development of an adhesion system increases the clinical use of composite resin and leads to sealing of the cavity walls and margins and significantly reduces secondary caries. Margins in the enamel bond better than dentinal margins; which are more susceptible to microleakage [18-20].

Primary and permanent teeth have many structural and morphological differences. Therefore, results from studies on permanent teeth cannot be extrapolated to primary teeth in most occasions. However, studies on laser irradiation in primary teeth for cavity preparation before adhesive use are sparse [21].

Self-etch adhesive systems consist of aqueous mixtures of acidic functional monomers (mostly esters of phosphoric acid) without the need for separate acid etching and subsequent rinsing methods. Acid monomers partially dissolve hydroxyapatite structure; therefore, primers penetrate into the collagen network [22-24]. Generally, self-etch adhesives are the preferred substances due to their ability to eliminate the washing and drying steps, save procedure time, and decrease procedural errors [21].

Yamada et al. could not find a significant difference between acid etching and preparation by bur or laser regarding microleakage [25].

Setien et al. evaluated the effect of preparation devices on microleakage of class V composite restorations. They found that if enamel is etched before adhesive application, microleakage will not occur in any of the methods of preparation [26]. This study was designed to evaluate the effect of tooth preparation with Er:YAG laser and bur on microleakage of two dentin adhesives in primary teeth.

MATERIALS AND METHODS

This was an experimental study on 80 canine primary teeth; which were extracted for orthodontic treatment during a 3-month period. Samples were kept in normal saline solution before the study, and were disinfected using 0.2% thymol [27]. Classic Class V cavities were prepared on the labial surface with incisal and gingival margins in enamel. The gingival margin was placed about 1 mm above the cementoenamel junction (CEJ).

The size of cavities standardized by a probe. Mesiodistal and occlusogingival widths were 4 mm, and 3 mm, respectively with 1.5 mm depth. After preparation of 5 cavities, the bur was changed. The samples were randomly divided into four groups. Two groups (first and third) were prepared by a diamond bur #008 (Tizkavan, Iran) and two groups (second and fourth) were prepared by Er:YAG laser (Fotona, Fidelis plus III, Slovenia) with 2940nm wavelength, energy = 250mJ and power = 2.5 W in enamel and energy = 200mJ and power = 2 W in dentin. The frequency was 10 Hz and pulse width was very short pulse (100 micro-seconds). Water spray and air spray were set on 7 and 4(ml/min), respectively. A non-contact laser handpiece (R02-C-919) was used. Standardization of the distance (12 mm) was performed by an endodontic K-file attached to the head of the handpiece (0.9 mm spot size at the focal point). Two different adhesive systems were used and the teeth were filled with composite resin. For groups 2 and 3, etch and rinse adhesive (Adper Single Bond, 3M ESPE, St. Paul, USA) was used; and for groups 1 and 4 one-step self-etch adhesive (Adper Prompt L-Pop, 3M, ESPE, St. Paul, USA) was used. The teeth were filled with composite resin (Filtek Z 250, 3M, ESPE, St. Paul, MN, USA). In groups 2 and 3 enamel and dentin were etched by 37% phosphoric acid for 15 seconds. After rinsing, two layers of Adper Single Bond were applied according to the manufacturer's instructions. In groups 1 and 4 after preparation of the cavity, Adper Prompt L-Pop was applied according to the manufacturer's instructions. In applying Prompt L-Pop, first the two liquids are sequentially combined and the resulting combined liquid is used to wet a disposable applicator. Then using this applicator the combined liquid is applied to the enamel and dentin for 15 seconds. After evaporating the solvent with a gentle application of compressed air, curing was performed for 10 seconds. All cavities were restored by a microhybrid composite resin (Filtek Z250, shade A2) in one layer and were cured for 40 s by a light-curing device (Coltolux, Coltene, USA) with 500 mW/cm2 intensity. After restoration, all specimens were kept at room temperature for 24 hours and then were polished by a white disc (KENDA, Liechtenstein). The specimens were thermocycled (Vafaei, Iran) at 700 rpm [27] in water baths between 5°C and 55°C with dwelling time of 60s and transforming time of 5s. Then, specimens were dried, sticky wax was applied to the apices and they were covered by two layers of nail polish except for 1 mm around the restoration margins. The specimens were then immersed in 2% methylene blue solution for 24 hours and then washed [17]. All samples were soaked in autopolymerizing acrylic resin (Acropars, Marlic Medical Industries Co.). Next, the centers of the specimens were sectioned buccolingually by a disc (D & Z, Germany). All sections were evaluated under 20X magnification of a stereomicroscope (ZTX-3E, China). The extent of microleakage was scored 0 to 3 by two blind evaluators and according to standardized criteria [18]:

0: No leakage visible at tooth/restoration interface;

1: Penetration of dye along the cavity wall, but less than ½ the length;

2: Penetration of dye along the cavity wall, but short of the axial wall;

3: Penetration of dye to and along the axial wall.

Both slices from each tooth were analyzed and the worst scores were used for data analysis. Data was analyzed by SPSS (ver. 16) using the Kruskal-Wallis test and Dunn's procedure.

RESULTS

Eighty teeth were evaluated in this study. Table 1 shows the frequency of microleakage in four study groups.

Table 1. Frequency Distribution of Microleakage in four study groups.

Microleakage	Study groups (number, percent)			
	Bur and self-etch	Laser and etch	Bur and etch	Laser and self-etch
0	3 (15)	4 (20)	10 (50)	1 (5)
1	2 (10)	4 (20)	5 (25)	2 (10)
2	5 (25)	2 (10)	4 (20)	8 (40)
3	10 (50)	10 (50)	1 (5)	9 (45)

Kruskal-Wallis test showed a significant difference among the four groups regarding microleakage ($P<0.001$). The least micro-leakage was observed in the third group (i.e. bur and etch & rinse); which was significantly lower than other groups.

Dunn's procedure showed statistically significant differences between groups 1 and 3 ($P=0.001$), 2 and 3 ($P=0.005$) and 3 and 4 ($P\leq0.001$). Level of significance was set at $P<0.0083$.

DISCUSSION

In this laboratory study, the amount of microleakage of composite restorations in class V cavities in primary canines prepared by Er:YAG laser and bur and two adhesive systems (self-etch and etch & rinse) was assessed by dye penetration method. Laser is used in pediatric dentistry due to such advantages as being free from noise and vibration, no tissue contact and a lower amount of local anesthesia; thus, treatment of children is done with less trauma and it is easier to control their behavior [28]. Microleakage is one of the most important challenges in restorative dentistry [18]. This phenomenon is caused when proper adaptation between restorative margins and tooth margins does not exist [21]. In this study dye penetration, a simple and inexpensive method, was used for evaluation of microleakage [29]. Thermocycling was also used for aging of the restoration material to consider the difference in thermal expansion coefficient [18]. Yamada et al, (2002), Kohara et al, (2002), Hossain et al, (2002), and Borsatto et al. (2006) have previously studied laser for preparing composite restorations in primary teeth, but their studies were not comparable to our study regarding the methods used [25, 29, 30, 31]. Yamada et al. and Kohara et al. both used Er:YAG laser and found that microleakage in composite restorations prepared by laser and without etch was significantly lower than cavities prepared by bur and etch [25, 29].

Hossain et al. used Er, Cr:YSGG laser and found that treatment by laser can omit acid etching [31]. Er:YAG laser can not substitute for etching [18]; thus, in our study we used etching as well. Recently, another study on primary teeth compared the effect of 5 adhesives on the microleakage of compomer restorations in class V cavities prepared by Er, Cr:YSGG laser.

They found the least amount of microleakage in Adper Single Bond 2 and Scotchbond Multi-purpose plus adhesives. They used adhesive etch and rinse similar to our study but their laser and restorative substance were different from ours [21]. Studies similar to the current study have been mostly conducted on permanent teeth. It has been shown that the bond strength is lower in primary dentin and it is probably more sensitive to acid conditioning than permanent teeth. Therefore, the time of this process probably needs to be lowered in the primary teeth [21]; although in this study we used the recommended times for permanent teeth. In our study microleakage in the laser group of, adhesive etch & rinse was higher than the group with bur and the same adhesive which was consistent with the study conducted by Yaman BC; although they used different adhesives and their study was done on permanent teeth [32]. It is believed that laser can make the surface resistant to acid; because it increases calcium phosphor proportions and decreases carbonate phosphor proportions resulting in a more resistant structure to acid and decay [33].

Ceballos also stated that decreased bond strength due to laser is because of dentin ablation that fuses collagen fibrils and decreases interfibrillar space causing a reduction in resin diffusion into intertubular spaces and consequently less intertubular retention [34]. Other studies have also reported a higher microleakage in composite restorations after preparation by laser, which is in agreement with the results of the current study [15, 28, 35].

Korkmaz et al. found a higher microleakage in occlusal margins of class V cavities prepared by Er:YAG laser using all-in-one self-etch adhesives and nano-composite which was inconsistent with our study [22]. Corona et al. used Er:YAG laser for cavity preparation and compared amalgam bond, glass ionomer and composite and reported a higher microleakage in laser-prepared cavities compared to bur-prepared ones which was in agreement with the current study [35]. However, their method was somewhat different from our study; because for conditioning they used Er:YAG laser as well. They also did not find a significantly different microleakage between etch & rinse and self-etch systems consistent with our results [35]. Their method was different from our study because they used a laser with different parameters (700mJ/pulse energy for enamel and 600 mJ/pulse for dentin, frequency of 10 Hz and 2 mm distance) and they studied bovine teeth; which surely have different properties. In the current study, microleakage in cavities prepared by bur and adhesive etch & rinse was significantly lower than bur and self-etch adhesive consistent with the results of many previous studies; because self-etch adhesives cannot efficiently etch the cavities and non-soluble calcium phosphate is not removed by rinsing [21].

CONCLUSION

This study showed that cavities prepared by Er:YAG laser had a higher microleakage compared to bur-prepared cavities when adhesive etch and rinse was used. The amount of microleakage was not significantly affected when a cavity was prepared by laser and self-etch primer.

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