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SHEAR BOND STRENGTH OF COMPOSITE RESIN AND CONVENTIONAL FLOWABLE COMPOSITE IN PRIMARY MOLARS PREPARED BY BOND PREP MODE AND CUTTING MODE ER, CR:YSGG LASER (AN IN VITRO STUDY)

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ABSTRACT

Introduction: Recently laser usage became popular in pediatric dentistry due to its efficiently in cutting enamel and dentin without pain, and with lesser vibration and noise, which leads to roughness in the structure of dental tissue like the etching process, which is the first indication for composite restorations cavity preparation. Due to the morphological differences and heterogeneous composition, of primary teeth compared to permanent teeth, the parameters of laser should be differently set. **Materials and methods:** This study was conducted to evaluate and compare the effect of bond prep mode and cutting mode of Er, Cr: YSGG laser in primary molars on shear bond strength of composite resin and conventional flowable composite using applied on flattened buccal and lingual surface on forty-eight freshly extracted sound natural deciduous molars divided into 2 groups and each group is subdivided into 2 subgroups each according to the mode of preparation: into: group 1: bond prep mode Er,Cr:YSGG laser which were further divided into: subgroup A: composite resin and subgroup B: conventional flowable composite, and group 2: cutting mode Er,Cr:YSGG which were further divided into: subgroup A: composite resin and subgroup B: conventional flowable composite. The samples were subjected to universal testing machine. **Results:** The mean (SD) values for shear bond strength of Bond prep and cutting modes regardless of restorative material were 22.8 (2.7) and 19.4 (2.7), respectively. Bond prep mode showed statistically significantly higher mean shear bond strength than cutting mode (P-value <0.001, Effect size = 0.296). The mean (SD) values for shear bond strength of composite resin and conventional flowable composite regardless of preparation mode were 20.7 (3.1) and 21.4 (3.3), respectively. There was no statistically significant difference between the two restorations (P-value = 0.394, Effect size = 0.017). **Conclusion:** The bond prep mode is better than cutting mode, Er,Cr:YSGG Laser irradiation improves shear bond stress and no significant difference between composite resin and conventional flowable composite clinically.

KEY WORDS: Shear bond strength, Er,Cr:YSGG Laser, Bond prep mode, Cutting mode, Composite Resin, Conventional Flowable Composite.

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INTRODUCTION

In the last few years, research in dental field showed improvement in both restorative techniques and materials to mimic the appearance and characteristics of the dental tissues lost due to caries. The adhesive resin restorative systems showed development which enabled cavity preparation without more extension into sound tooth structure[1-3]. in which the essential factor for long-term clinical success of esthetic restoration is the shear bond strength (SBS)[4-6].

The increased demand for cosmetics and tooth structure preservation leads to the development of adhesive restorative materials which bond to the enamel and dentin, where flowable composite resin is a type of adhesive restorative materials that gained popularity from its low viscosity, which lead to less tooth preparation in preventive resin restorations and superficial restorations[7,8].

A growing debate in the recent years on the various applications of lasers in cavity preparation due to their efficiency in enamel and dentin removal[7,9]**.** Recently the popularity of laser usage in pediatric dentistry was due to its efficiently in cutting enamel and dentin without pain, and with lesser vibration and noise[10]. The U.S. Food and Drug Administration approved Er:YAG and Er,Cr:YSGG, removal of hard dental tissues without damaging surrounding structures[11,12]. The best parameters for conditioning of the hard tissues of the tooth are done by pulsed erbium lasers due to the process thermomechanical ablation that results in roughness in the structure of dental tissue like the etching process[7], due to high efficiency of laser absorption by both water and hydroxyapatite in enamel and dentin[1], which is the first indication for composite restorations cavity preparation[7,13,14]. When the Er,Cr:YSGG laser is accompanied by water spray during irradiation of hard dental tissues, not only temperature suppression, but also increase in the efficiency of cutting occurs. The alterations of the enamel and dentin surface that occurs after irradiation by Er,Cr:YSGG laser are surfaces micro-irregularities, beside no smear layer[11,15-17].

Several studies have shown that smear layer can be removed by Er: YAG laser, together with opening of dentinal tubules and creation of a rough surface[4,6,18-20]. The dentin of primary tooth is characterized by lower mineralization content, higher organic material, and water content when compared to permanent teeth, where dentinal tubules have low thickness and density, about 0.4-0.5 mm to pulp surface[4,18,21,22] so, taking into consideration all these morphological differences and heterogeneous composition, the setting of the parameters of laser in primary teeth should be different[4,18,120-22]. As fewer studies on laser irradiation in the primary teeth were done for cavity preparation for composite resin restorations[4], so this study is conducted to evaluate and compare the effect of bond prep mode and cutting mode of Er, Cr: YSGG laser in the primary molars on shear bond strength of composite resin and conventional flowable composite using universal testing machine.

MATERIALS AND METHODS

A forty-eight unidentified human primary molars with at least intact one buccal or lingual surface which were either exfoliated due to physiologic reason or are indicated for extraction. Teeth having caries on buccal or lingual surfaces or both, hypoplastic, hypocalcified, fractured crown due to extraction, and with any developmental anomaly were rejected. The teeth were washed under running water, cleaned of residual tissue and debris, then autoclaved and stored in distilled water at 4°C for not more than 1 week [4,22]. The forty-eight teeth were divided into 2 groups and each group is subdivided into 2 subgroups each according to the mode of preparation as follows: group 1: bond prep mode Er,Cr:YSGG laser which were further divided into: subgroup A: composite resin and subgroup

B: conventional flowable composite, and group 2: cutting mode Er,Cr:YSGG which were further divided into: subgroup A: composite resin and subgroup B: conventional flowable composite.

Tooth surface preparation (substrate):

The forty-eight samples were embedded in acrylic resin in a standardized autoclavable Teflon molds. In group 1, buccal surface was flattened (bond prep mode) with Er,Cr:YSGG laser (Waterlase iPlus, Biolase; Irvine, CA,USA) using a Waterlase iplus Gold handpiece and aMGG6 tapered sapphire tip having a fiber core diameter of 600 µm. The laser settings were 4.5 W (peak power), frequency 50 Hz, air pressure 60%, and water pressure 80%, used in non-contact mode in 24 samples. In group 1A (12 samples) composite resin (Z-250, 3M/ESPE) was applied on prepared surfaces of dentin. In group 1B (12 samples) conventional flowable composite (3M/Dental Product, USA) was applied on prepared surfaces of dentin. For group 2, lingual surface was roughened (cutting mode) with Er,Cr:YSGG laser (Waterlase iPlus, Biolase; Irvine, CA,USA) using a Waterlase iplus Gold handpiece and aMGG6 tapered sapphire tip having a fiber core diameter of 600 µm till yellow dentin was seen. The laser settings were 6 W (peak power), frequency 15 Hz, air pressure 60%, and water pressure 80% in 24 samples. In group 2A (12 samples) composite resin (Z-250, 3M/ESPE) was applied on prepared surfaces of dentin. In group 2B (12 samples) conventional flowable composite (3M/Dental Product, USA) was applied on prepared surfaces of dentin.

Restorative Material Application

For all specimens of group 1, two layers of bonding agent (Adper single bond, 3MESPE, USA) were applied on the etched surfaces and light cured for 20 s (Arialux, ApadanaTak, Iran) with output of 450 mW/cm2, according to the manufacturer's instructions[4]. Standardized cylinders of composite resin and conventional flowable composite were applied to the prepared tooth surfaces by the aid of a specially designed Teflon mold with standardized dimension.

For all specimens of group 2, the dentin surfaces were etched with 37% phosphoric acid gel for 10 seconds and rinsed for 20 seconds, followed by application of two layers of bonding agent (Adper single bond, 3MESPE, USA) on the etched surfaces and light cured for 20 seconds (Arialux, ApadanaTak, Iran) with output of 450 mW/cm2, according to the manufacturer's instructions[4]. Standardized cylinders of composite resin and conventional flowable composite were applied to the prepared tooth surfaces by the aid of a specially designed Teflon mold with standardized dimension.

Shear Bond Strength Testing

All samples of groups 1a, 1b, 2a, and 2b were subjected to shear bond strength test using Instron universal testing machine (Instron, Norwood, USA) at a cross head speed of 0.5mm/min until fracture. The specimen was placed in the lower assembly of the machine and the force was applied with the help of a knife-like mandrel which engages the cylinders of GI and RMGI at the tooth restoration interface to test the strength of the bond. Data were recorded using BlueHill computer software.

Statistical Analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Shear bond strength data showed normal (parametric) distribution. Data were presented as mean, standard deviation (SD) and 95% Confidence Interval for the mean (95% CI) values. Two-way Analysis of Variance (ANOVA) was used to study the effect of preparation mode, restorative material and their interaction on mean shear bond strength. Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

Descriptive statistics for shear bond strength values (MPa) in the different groups are presented in Table 1. Two-way ANOVA results showed that regardless of restorative material; preparation mode had a statistically significant effect on mean shear bond strength (*P*-value <0.001, Effect size = 0.296). Regardless of preparation mode; restorative material had no statistically significant effect on mean shear bond strength (*P*-value = 0.394, Effect size = 0.017). The interaction between the two variables had no statistically significant effect on mean shear bond strength (*P*-value = 0.702, Effect size = 0.003). Since the interaction between the variables is not statistically significant, so the variables are independent from each other (Table 2).

The mean (SD) values for shear bond strength of Bond prep and cutting modes regardless of restorative material were 22.8 (2.7) and 19.4 (2.7), respectively (figure 1). Bond prep mode showed statistically significantly higher mean shear bond strength than cutting mode (*P*-value <0.001, Effect size = 0.296).

The mean (SD) values for shear bond strength of composite and flowable composite regardless of preparation mode were 20.7 (3.1) and 21.4 (3.3), respectively (figure 2). There was no statistically significant difference between the two restorations (*P*-value = 0.394, Effect size = 0.017).

Table 3 represents the interaction of variables. The results showed that Bond prep mode showed statistically significantly higher mean shear bond strength than cutting mode whether using composite resin (*P*-value = 0.002, Effect size = 0.199) or with conventional flowable composite (*P*-value = 0.008, Effect size = 0.148). Comparison between the two restorative materials revealed that there was no statistically significant difference between composite resin and conventional flowable composite whether using Bond prep mode (*P*-value = 0.738, Effect size = 0.003) or cutting mode (*P*-value = 0.383, Effect size = 0.017) (figure 3).

TABLE (1) Descriptive statistics for shear bond strength values (MPa)

Preparation mode	Restorative material	Mean	SD	95% CI	
				Lower bound	Upper bound
Bond prep	Composite resin	22.6	2.7	21	24.2
	Conventional flowable composite	23	2.8	21.3	24.6
Cutting	Composite resin	18.9	2.3	17.3	20.5
	Conventional flowable composite	19.9	2.7	18.3	21.5

TABLE (2) Two-way ANOVA results for the effect of different variables on mean shear bond strength

Source of variation	Type III Sum of Squares	df	Mean Square	*F*-value	*P*-value	Effect size *(Partial eta squared)*
Preparation mode	137.702	1	137.702	18.460	<0.001*	0.296
Restorative material	5.535	1	5.535	0.742	0.394	0.017
Preparation mode x Restorative material interaction	1.110	1	1.110	0.149	0.702	0.003

*df: degrees of freedom = (n-1), *: Significant at $P \leq 0.05$*

TABLE (3) The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between shear bond strength values with different interactions

Restorative material	Bond prep		Cutting		*P*-value (Between modes)	Effect size *(Partial eta squared)*
	Mean	SD	Mean	SD		
Composite	22.6	2.7	18.9	2.3	0.002*	0.199
Flowable composite	23	2.8	19.9	2.7	0.008*	0.148
P-value (Between materials)	0.738		0.383			
Effect size *(Partial eta squared)*	0.003		0.017			

**: Significant at P ≤ 0.05*

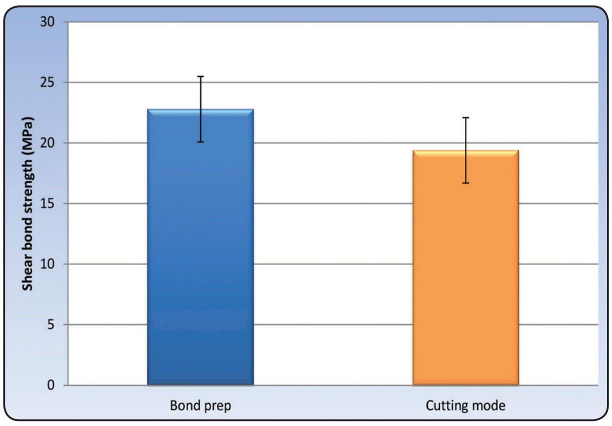

Fig. (1): Bar chart representing mean and standard deviation values for shear bond strength of preparation modes regardless of restorative material

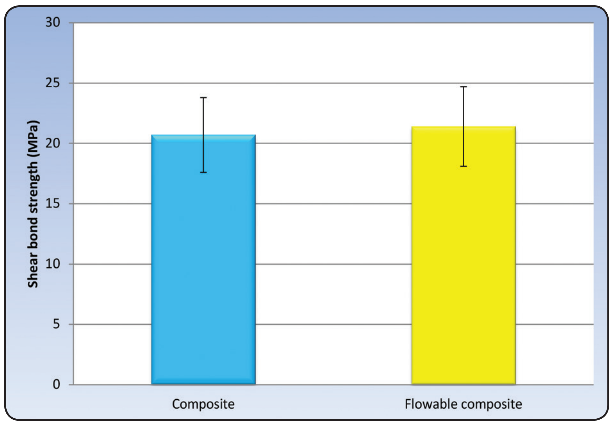

Fig. (3): Bar chart representing mean and standard deviation values for shear bond strength with different interactions of variables

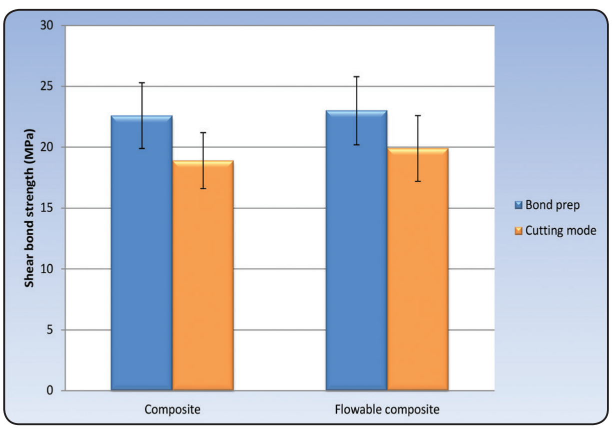

Fig. (2): Bar chart representing mean and standard deviation values for shear bond strength of the two restorative materials regardless of preparation mode

DISCUSSION

In the present study, shear bond strength test was used, because shear stresses are considered the major stresses responsible for bond failures of restorative materials clinically[1], therefore, shear bond strength test is the most reliable method for assessing the restoration clinical performance[1,4].

The ability of different settings of erbium lasers in improving bond strength and marginal seal have been assessed in some studies, where a wide range of results were reported[7,23]. In the current study two different laser settings was used in this study which are 4.5 W and 6 W to determine the most effective setting. In a study done by Gurgan et al 2008[1] the power level (5 W) was used for irradiation of dentin surface, which was higher than that suggested by the manufacturer (4 or 4.5 W), and they concluded that the best shear bond strengths were gained with the high power levels which disagree with the current study. In a study done by Sung et al. 2005[24] they discovered that higher shear bond strengths of human primary teeth dentin was achieved with Er,Cr:YSGG laser with parameters of 4 and 5 W for preparation, and 0.75 W for etching[1], which may agree with the current study.

In the current study the bond prep showed higher shear bond strength than the cutting mode with both materials, due to the bond prep leads to roughness with no smear layer, which may be attributed to the water content and organic material, which is higher and with more irregular dentinal tubules in the dentin of the primary teeth when compared to dentin of the permanent teeth, and also, in primary teeth the water content in inter-tubular dentin is more than intra-tubular dentin, which means that using similar power of laser will remove higher amount of tissue in the deciduous teeth, so the parameters used in the deciduous teeth should be lower than those used in the permanent teeth[18,22].

It is well known that restorative composites have a hydrophobic nature, which complicates their bonding to hard dental tissues, therefore bonding of these resins necessitates the alteration of the topography of the tooth surface and use hydrophilic resins[1-3,25]. In a study done by Gurgan et al. 2008[1], modification of the surface morphology was done by cutting the tooth surface with a bur and Er,Cr:YSGG laser, and then conditioning of the surfaces with a bonding agent with or without phosphoric acid or with self-etching primer, and treating the surfaces by laser with different energy settings, they concluded that laser may have a positive effect and increase bond strength versus traditional preparation by bur, which depends on the adhesive system used which was consistent with the results of this study.

The lased dentin surface results in improvement of the bonding ability of the surface due to its scaly and flaky appearance after laser irradiation[23]. In a study done by Bahrololoomi and Ghafourifard 2016[4] showed that laser irradiation produces an adhesion pattern that will enhance the bonding process which was in agreement with the results of Hossain et al. 2001[26], Visuri et al. 1996 [27], Hibst et al. 1989[28], Wanderly et al. 2005 [20] and Mahmoudian et al. 2011 [29], also similar results was achieved, when a study was conducted by Sung EC 2005 [24] using a different type of Er, Cr: YSGG laser, accordingly was consistent with the results of the current study.

In a study done by Line et al. 1999[30] they reported that for non-etched enamel the bond strength was highly elevated in case of surfaces cut by the Er,Cr:YSGG laser when compared to surfaces cut by bur, although regarding the two dentinal groups, no difference was reported. In a study conducted by Remos et al. 2002[31] they found that all subgroups irradiated by laser showed a decrease in bond strength when compared to control groups, especially when single-bottle bonding agents were used. In a study done by Sakakibara 1999[32], Dunn et al.[19] and Ceballo et al. 2002[33] lower shear bond stress have found after laser irradiation. They postulated that a layer of rather denatured collagen fibers was created following laser irradiation with poor adhesion to dentin surface which don't contain peri-fibrillar spaces and may limit penetration of the resin to inter-tubular dentin subsurface and weaken the hybrid layer formation[33], which was on the contrary to the results of the current study.

In a study conducted by Van Meerbeek et al. 2003[34] they stated that micro-explosions induced by the laser treatment due to its thermo-mechanical ablation, which firstly will lead to water and then other hydrated organic components of the tissue to vaporize, this vaporization in turn causes internal pressure to increases in the tissue until explosive destruction of the inorganic components of the surface occurs. Since the water content of intertubular dentin is higher than mineral content in comparison to peritubular dentin, so, it is selectively more ablated, leaving dentinal tubules protruding with a cuff-like appearance[35]. This may be responsible for the increase in the adhesive area together with the absence of the smear layer, which are additional factors that may improve bonding to dentin treated by laser, which may be explained by the formation of resin tag providing mechanical retention and infiltration of adhesive resin into the micro-irregularities in lased demineralized dentin[1]. Furthermore, images taken by scanning electron microscopic reveals that laser irradiation creates a surface that elevates the retention of composite restorative materials[7,36]. So, briefly we can assume that Er,Cr:YSGG laser elevates shear bond strength in composite resin and conventional fowable composite restorative materials for primary teeth through improving bonding process, but with no significant difference between the two restorative materials.

CONCLUSION

The following can be concluded as regards the results of the current laboratory study:

1) Bond prep mode is better than cutting mode regarding shear bond strength.
2) Er,Cr:YSGG Laser irradiation improves shear bond stress.
3) No significant difference between composite resin and conventional flowable composite concerning shear bond strength.

REFERENCES

1. Gurgan S, Kiremitci A, Cakir FY, Gorucu J, Alpaslan T, Yazici E, Gutknecht N. Shear Bond Strength of Composite Bonded to Er,Cr:YSGG Laser-Prepared Dentin. Photomed. Laser Surg 2008; 26(5):495–500.
2. Van Meerbeek B, De Munck J, Yoshida Y. Adhesion to enamel and dentin: current status and future challenges. Oper Dent. 2003; 28:215–235.
3. Peumans, M, Kanumilli P, De Munck J, Landuyt V, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater. 2005; 21:864–881.
4. Bahrololoomi Z, Ghafourifard R. Shear Bond Strength of Primary Teeth Dentin Irradiated with Different Erbium-doped Yttrium Aluminium Garnet Laser Energies and Scanning Electron Microscope Study of Dentin Morphology. J Inter Oral Health 2016; 8(10):943-947.
5. Gökçe B. Effects of Er: YAG laser irradiation on dental hard tissues and all-ceramic materials: SEM evaluation. In: Kazmiruk V. (Editor). Scanning Electron Microscopy, USA: In Tech; 2012; 179-212.
6. Shirani F, Birang R, Malekipur MR, Zeilabi A, Shahmoradi M, Kazemi S. Adhesion to Er: YAG laser and bur prepared root and crown dentine. Aust Dent J. 2012; 57(2):138-43.
7. Ansari ZJ, Fekrazad R, Feizi S, Younessian F, Kalhori K AM, Gutknecht N. The effect of an Er,Cr:YSGG laser on the micro-shear bond strength of composite to the enamel and dentin of human permanent teeth. Lasers Med Sci. 2012; 27:761–765.
8. Poorzandpoush K, Shahrabi M, Heidari A, Hosseinipour ZS. Shear Bond Strength of SelfAdhesive Flowable Composite, Conventional Flowable Composite and Resin-Modified Glass Ionomer Cement to Primary Dentin. Front Dent. 2019; 16(1):62-68.
9. Gholami GA, Fekrazad R, Esmaiel-Nejad A, Kalhori KA. An evaluation of the occluding effects of Er,Cr:YSGG, Nd:YAG, CO2 and diode lasers on dentinal tubules: a scanning electron microscope in vitro study. Photomed Laser Surg. 2011; 29(2):115–121.
10. Roberson M, Theodore M, Haymann OH, Swift EM, Sturdevant C (2002) Sturdevant's art and science of operative dentistry, 4th edn. St. Louis: The C.V. Mosby Co., Chap 5: 177–179.
11. Lee BS, Lin PY, Chen MH, Hsieh TT, Lin CP, Lai JY, Lan WH. Tensile bond strength of Er,Cr:YSGG laser-irradiated human dentin and analysis of dentin-resin interface. Dent Mater. 2006; 23:570–578.
12. Hossain M, Nakamura Y, Tamaki Y, Yamada Y, Murakami Y, Matsumoto K. Atomic analysis and Knoop hardness measurement of the cavity floor prepared by Er,Cr:YSGG laser irradiation in vitro. J Oral Rehabil. 2003; 30:515–521.
13. Hossain M, Nokemura Y, Yamads Y, Murakami Y, Matsumoto K. Microleakage of composite resin restoration in cavities prepared by Er,Cr:YSGG laser irradiation and

etched bur cavities in primary teeth. J Clin Pediat Dent. 2002; 26(3):263–268.

14. Kohara EK, Hossain M, Kimora Y, Matsumote K, Inoe M, Sasa R. Morphological and microleakage studies of the cavities prepared by Er:YAG laser irradiation in primary teeth. J Clin Laser Med Surg. 2002; 20(3):141–147.
15. Eversole, LR, Rizoiu IM. Preliminary investigations on the utility of an erbium, chromium YSGG laser. J Can Dent Assoc. 1995; 23:41.
16. Hossain M, Nakamura Y, Yamada Y, Murakami Y, Matsumo K. Microleakage of composite resin restoration in cavities prepared by Er,Cr:YSGG laser irradiation and etched bur cavities in primary teeth. J Clin Pediatr Dent. 2002; 26:263–268.
17. Hossain M, Nakamura Y, Yamada Y, Kımura Y, Matsumoto N, Matsumo K. Effects of Er,Cr:YSGG laser irradiation in human enamel and dentin ablation and morphological studies. J Clin Laser Med Surg. 1999; 17:155–159.
18. Zhang S, Chen T, Ge LH. Scanning electron microscopy study of cavity preparation in deciduous teeth using the Er: YAG laser with different powers. Lasers Med Sci 2012; 27(1):141-4.
19. Dunn WJ, Davis JT, Bush AC. Shear bond strength and SEM evaluation of composite bonded to Er: YAG laser-prepared dentin and enamel. Dent Mater. 2005; 21(7):616-24.
20. Wanderley RL, Monghini EM, Pecora JD, Palma-Dibb RG, Borsatto MC. Shear bond strength to enamel of primary teeth irradiated with varying Er: YAG laser energies and SEM examination of the surface morphology: An in vitro study. Photomed Laser Surg. 2005; 23(3):260-7.
21. Kowsari A, Seraj B. An evaluation on shear strength of composite resin bonded to primary teeth dentin after Nd: YAG laser radiation. J Dent Med. 2002; 15(1):46-54.
22. Scatena C, Torres CP, Gomes-Silva JM, Contente MM, Pécora JD, Palma-Dibb RG, et al. Shear strength of the bond to primary dentin: Influence of Er: YAG laser irradiation distance. Lasers Med Sci. 2011; 26(3):293-7.
23. Stiesch-Scholz M, Hanning M. In vitro study of enamel and dentin marginal integrity of composite and compomer restorations placed in primary teeth after diamond or Er:YAG laser cavity preparation. J. Adhesive Dent. 2002; 2:213–222.
24. Sung, E.C., Chenard, T., Caputo, A.A., Amodeo, M., and Chung, E.M. Composite resin bond strength to primary dentin prepared with Er,Cr:YSGG laser. J. Clin Pediatr Dent. 2005; 30, 45–49.
25. Trajtenberg CP, Pereira PNR, Powers JM. Resin bond strength and micromorphology of human teeth prepared with an erbium:YAG laser. Am. J. Dent. 2004; 17, 331–336.
26. Hossain M, Nakamura Y, Yamada Y, Suzuki N, Murakami Y, Matsumoto K. Analysis of surface roughness of enamel and dentin after Er,Cr: YSGG laser irradiation. J Clin Laser Med Surg 2001; 19(6):297-303.
27. Visuri SR, Gilbert JL, Wright DD, Wigdor HA, Walsh JT Jr. Shear strength of composite bonded to Er: YAG laserprepared dentin. J Dent Res 1996; 75(1):599-605.
28. Hibst R, Keller U. Experimental studies of the application of the Er: YAG laser on dental hard substances: I. Measurement of the ablation rate. Lasers Surg Med 1989; 9(4):338-44.
29. Mahmodian J, Afshar H, Darvish H, FekrAzad R. Comparison between shear bond strength of composite resin following surface conditioning with Er Cr YSGG laser and acid etch on the enamel surface in primary canines. J Islamic Dent Assoc Iran 2011;23(2):105-9.
30. Lin S, Caputo AA, Eversole LR, Rizoiu I. Topographical characteristics and shear bond strength of tooth surfaces cut with a laser-power hydrokinetic system. J Prosthet Dent. 1999; 82(4):451–455.
31. Ramos RP, Chimello DT, Chinellati MA, Nonaka T, Percora JD, Palme Dibb RG. Effect of Er:YAG laser on bond strength to dentin of a self-etching primer and two single-bottle adhesive systems. Lasers Surg Med. 2002; 31(3):164–170.
32. Sakakibara Y. A study on bond strength to dentin irradiated by erbium: YAG laser. Jpn J Conserv Dent 1998; 41:207-19.
33. Ceballo L, Toledano M, Osorio R, Tay FR, Marshall GW. Bonding to Er-YAG-laser-treated dentin. J Dent Res 2002; 81(2):119-22.
34. Van Meerbeek B, Munck JD, Mattar, D, Landuyt, KV, Lambrechts, P. Microtensile bond strengths of an etch & rinse and self-etch adhesive to enamel and dentin as a function of surface treatment. Oper Dent. 2003; 28:647–660.
35. Aoki A, Ishikawa I, Yamada T. Comparison between Er:YAG laser and conventional technique for root caries treatment in vitro. J Dent Res. 1998; 77:1404–1414.
36. Hoke JA, Burkes EJ Jr, Gomes ED, Wolbarsht ML. Erbium: YAG (2.49 mum) laser effects on dental tissues. J Laser Applic. 1999; 2 (3–4):61–65.