Comparison of marginal microleakage of flowable composite restorations in primary canine teeth prepared with high-speed diamond bur, Er:YAG laser and Er,Cr:YSGG laser

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Background and Objectives: Adhesive restorations have become highly popular in pediatric dentistry, and novel methods of cavity preparation with minimal patient discomfort including Er:YAG and Er,Cr:YSGG laser preparations have greatly advanced. This study aimed to compare the microleakage of composite restorations of class V cavities prepared in primary canine teeth with high-speed bur and Er:YAG and Er,Cr:YSGG lasers.

Materials and Methods: This in vitro study was conducted on 30 class V cavities prepared on the buccal surfaces of primary canine teeth in three groups (n = 10) of bur preparation, Er:YAG laser and Er,Cr:YSGG laser. The cavities were etched, bonded and restored with Grandio flowable composite according to the manufacturer's instructions. After thermocycling, the teeth were immersed in 1% methylene blue dye for 24 hours to detect microleakage. The teeth were evaluated under a stereomicroscope at ×32 magnification to assess the depth of penetration of methylene blue. The data were analyzed using SPSS version 19 and non-parametric Kruskal-Wallis and Mann Whitney tests.

Results: Non-parametric Kruskal-Wallis test showed no significant difference in dye penetration among the three groups ($P > 0.05$). Pairwise comparisons of occlusal and gingival margins by non-parametric Mann Whitney test revealed no significant difference in microleakage either ($P > 0.05$).

Conclusion: Use of Er:YAG and Er,Cr:YSGG lasers can decrease microleakage to the level of bur preparation. Bur and laser cavity preparations are not significantly different in terms of microleakage at the enamel or dentin margins. Thus, considering the advantages of laser, it may serve as a suitable alternative to bur preparation in pediatric dentistry.

Key words: Er:YAG laser · Er,Cr: YSGG laser · microleakage · primaty teeth

Introduction

Methods to decrease patient discomfort and increase the success rate of treatment are highly demanded in pediatric dentistry. The main problem of rotary instruments is the adverse effect of generated heat and pres-

sure during their function on dental pulp, which can cause pain. Researchers have long been in search of easier and more conservative cavity preparation methods to minimize the generated heat, vibration and pain. Air abrasion, ultrasonic instruments, chemo-mechanical preparation and laser have been suggested as alternatives for caries removal. Use of hard tissue lasers has recently gained interest for cavity preparation since they are less traumatic, generate less noise and vibration and require no or minimal local anesthesia ¹⁻³).

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Received date: April 24th, 2017
Accepted date: July 14th, 2017

Introduction of erbium lasers enabled more efficient removal of enamel and dentin. Erbium lasers have two distinct wavelengths: Er:YAG laser with 2940 nm wavelength and Er,Cr:YSGG laser with 2780 nm wavelength. Erbium lasers have high affinity for hydroxyapatite and the highest absorption in water among dental lasers. They are the laser of choice for dental hard tissue ablation. They can also be used for soft tissues due to their high water content ⁴⁾.

Absorption of laser energy results in the phenomenon of hydrophotonics; which is defined as the interaction of laser wavelength with water droplets on the tissue surface and subsequent stimulation of water molecules and occurrence of micro-expansion, which leads to precise and clean tissue removal ^{1, 5, 6)}.

High demand for esthetic restorations has increased the use of composite resins; however, dental composites have shortcomings such as polymerization shrinkage, dimensional changes and subsequent gap formation at the tooth-restoration interface. The latter can result in development of secondary caries particularly in the cervical area and pathological changes in dental pulp ^{3, 7)}, marginal defects in restorations, fracture of restorations and failure of treatment in long-term ⁸⁾.

Several studies have assessed the microleakage of adhesive restorations in cavities prepared with erbium lasers. Some researchers have reported optimal results of cavity preparation with laser ⁹⁻¹¹⁾ while some others failed to show the optimal efficacy of laser in decreasing microleakage ^{3, 12, 13)}. This controversy may be due to the technique of laser irradiation or selective laser parameters. Thus, this study aimed to assess the marginal microleakage of flowable composite restorations

in class V cavities prepared in primary canine teeth by means of high-speed diamond bur and Er:YAG and Er,Cr:YSGG lasers.

Materials and Methods

This in vitro study was conducted on 30 sound primary canine teeth extracted for orthodontic reasons. The teeth were collected from several dental clinics using accidental convenience sampling after considering the exclusion criteria (caries, previous restorations, wear, cracks and visible developmental anomalies/defects). After cleaning the teeth with rotary instrument and eliminating the soft tissue residues, the teeth were immersed in 1% chloramine T solution for 24 hours for disinfection and were then stored in distilled water at 4°C until the experiment to prevent dehydration. The teeth were randomly divided into three groups (n = 10). Class V cavities were prepared on the buccal surfaces of the teeth with 3 mm mesiodistal dimension, 2 mm occlusogingival height and 1.5 mm depth, in such a way that the occlusal margin of the cavities was above the cemento-enamel junction in the enamel and their apical margin was beneath the cemento-enamel junction in the cementum or dentin. No beveling was done. (**figure1 and 2**)

In group one (control), the teeth were prepared with 008 diamond fissure bur (Kavo, USA) and high-speed hand piece under air and water spray. The bur was discarded after five preparations. In group two, cavities were prepared with Er:YAG laser (Smart 2940D Plus, Deka, Italy) with 200 mJ energy, 15 Hz frequency, 3 W power and 30% water (very short pulse). In group three, cavities were prepared with Er,Cr:YSGG

Figure 1

Figure 2

laser (WaterLase iplus, Biolase, U.S.A) with 200 mJ energy, 15 Hz frequency, 3W power and 60% air and 30% water using MZ8 tip.

The cavities were then etched with 35% phosphoric acid (Vocacid, Voco, Germany) for 30 seconds in the enamel margins and 15 seconds in the dentin margins as recommended by the manufacturer followed by rinsing for 30 seconds and drying for 15 seconds. Bonding agent was then applied on the cavities (Solobond M, Voco, Germany) according to the manufacturer's instructions and gently air sprayed for 30 seconds. Light curing was performed for 20 seconds using a QTH light-curing unit (Bonart, South-Korea) with a light intensity of 740 mW/cm².

Flowable composite (Grandio flow, Voco, Germany) was then applied to the cavities and light cured for 20 seconds. The cavities were then finished

and polished using finishing and polishing burs under water and air. Next, the apices were sealed with composite and the samples were subjected to 500 thermal cycles between 5 - 55°C in a thermocycler (Dorsa, Iran) and incubated at 37°C for 24 hours (Pars Azma Co., Iran). Next, the entire tooth surfaces, except for 1mm band around the restoration margins, were covered with two thin layers of nail varnish (**figure 3**) and after drying, the samples were immersed in 1% solution of methylene blue dye in water at 37°C for 24 hours. The samples were then rinsed and longitudinally sectioned at the center of restoration (**figure 4**). The samples were then evaluated under a stereomicroscope (SZX9, Olympus, Japan) at ×32 magnification to quantify dye penetration depth using a scoring system described in **Table 1** (**figure 5**).

All samples were inspected by the same observer.

Figure 3

Figure 4

Figure 5

The Kruskal Wallis test was used to assess possible differences among the study groups. The Mann Whitney test was applied for pairwise comparisons of microleakage at the occlusal and gingival margins between the groups. The data were analyzed using SPSS version 19. Patient consent was not required since the study had an in vitro design.

Results

Table 2 shows the frequency distribution of dye penetration scores at the occlusal and gingival margins in the three groups.

The non-parametric Kruskal-Wallis test found no statistically significant difference in terms of microleakage

in the occlusal (enamel) or gingival (dentin/cementum) margins among the three groups ($P > 0.05$) (**Table 3**).

Pairwise comparison of the groups using non-parametric Mann Whitney test revealed no significant difference in microleakage at the gingival or occlusal margins either ($P > 0.05$). Microleakage at the occlusal and gingival margins was not significantly different ($P > 0.05$) (**Table 4**).

Discussion

This study aimed to compare the microleakage of class V composite restorations in cavities prepared with three techniques namely bur preparation, Er:YAG laser and Er,Cr:YSGG laser in primary canine teeth.

Table 1: The scoring system used for quantification of dye penetration depth

Dye penetration score	Zero	One	Two	Three	Four
Occlusal margin	No dye penetration	Dye penetration at the tooth-restoration interface maximally extending to the dentinoenamel junction	Dye penetration at the tooth-restoration interface passing the dentinoenamel junction but not reaching the axial wall	Dye penetration at the tooth-restoration interface reaching the axial wall	Lateral dye penetration in dentin reaching dental pulp
Gingival margin	No dye penetration	Dye penetration to less than half the distance to the axial wall	Dye penetration extending by more than half the distance to the axial wall but not reaching the axial wall	Dye penetration to the axial wall	Dye penetration in dentin reaching dental pulp

Table 2: Frequency distribution of microleakage at the occlusal and gingival margins

Study group	Microleakage score	0	1	2	3	4	Total percentage
		Number and percentage	Number and percentage	Number and percentage	Number and percentage	Number and percentage	
Bur	Occlusal	1 10%	4 40%	4 40%	1 10%	0 0	10 100%
	Gingival	3 30%	5 50%	0 0	1 10%	1 10%	10 100%
Er:YAG	Occlusal	1 10%	4 40%	2 20%	1 10%	2 20%	10 100%
	Gingival	1 10%	3 30%	4 40%	0 0	2 20%	10 100%
Er,Cr:YSGG	Occlusal	0 0	1 10%	6 60%	1 10%	2 20%	10 100%
	Gingival	4 40%	2 20%	2 20%	1 10%	1 10%	10 100%

Marginal seal is a fundamental factor determining the longevity of adhesive restorations and plays an important role in survival, clinical service and overall success of these restorations ^{3, 7, 11, 14, 15}. Several methods have been suggested to decrease microleakage including beveling of enamel, use of adhesives, incremental application of composite and cavity preparation by laser ¹⁵. Considering the advantages of Er:YAG and Er,Cr:YSGG lasers in removing superficial tissues with no adverse thermal effects on the adjacent structures, we evaluated the efficacy of these lasers to decrease microleakage.

Microleakage assessment can be done in vivo and in vitro. However, in vitro studies are preferred due to their easy conduction and practicality. Evaluation of microleakage in vitro is done by use of dyes, chemical tracers, radioactive isotopes, air pressure, bacteria, neutron activation analysis, scanning electron microscopy, artificial caries and electrical conduction ¹⁶. Of the afore-mentioned techniques, dye penetration is among the oldest and most commonly used techniques for this purpose since gaps allowing the passage of bacteria are relatively large (0.05 μm) but toxins and other bacterial products sometimes pass through smaller gaps; thus, use of dye (dye penetration technique) is superior to bacteria (bacterial leakage model) ¹⁴. However, smaller size of some dye molecules than some pathogens is a shortcoming of this method ¹⁴. Several dyes are used for microleakage assessment such as 0.2% rhodamine, 1% methylene blue, 50% silver nitrate and 0.5% basic Fuchsin ⁶; methylene blue is preferred due to its high penetration ability, small particle size, low molecular weight, low cost and easy use ^{10, 15}.

In both class V and class II restorations, the apical (gingival) margin of the restoration is prepared in the root and leakage in this area is a clinical concern for clinicians ⁹. Selection of class V cavities in this study was based on more adjustable distance of laser

tip in class V compared to class II cavities as well as closer distance from the tip of the light curing unit to the composite surface in class V cavities ¹⁰.

Due to the differences in the coefficient of thermal expansion of tooth structure and restorative materials, thermal alterations in the oral cavity cause variable degrees of expansion and contraction in tooth and restoration, which lead to gap formation at the tooth-restoration interface and subsequent microleakage. Thermocycling is often performed to simulate the oral clinical setting ^{3, 14} and causes thermal fatigue stress and hydrolytic effects on the adhesive interface ^{11, 13}. Thermocycling has been performed for 200 to 1000 cycles in different studies ⁷. In the current study, we performed 500 thermal cycles. Also, we did not bevel the restoration margins to assess the actual effect of bur and laser preparation on microleakage ¹³. Moreover, we only used one type of composite for the purpose of standardization. Our findings did not reveal a significant difference in microleakage at the occlusal (enamel) or gingival (dentin/cementum) margins ($P > 0.05$). Pairwise comparisons of microleakage at the occlusal and gingival margins revealed no significant difference either ($P > 0.05$).

Fattah et al, ¹⁰ and Shafiei and Memarpour ¹¹ discussed that optimal surface properties of teeth subjected to laser irradiation such as surface energy, presence of moisture ⁹ and absence of smear layer ¹⁰ were probably responsible for lower microleakage in laser preparation compared to the use of bur. Moreover, Shahabi et al. ⁹ believed that following tissue ablation, some particles from the tooth surface are lost and micro- or macro-roughness of the surface occurs, which in addition to optimal surface energy and moisture of lased surface and suitable wetting of hydrophilic bonding agents, can result in optimal adhesion of adhesive restorative materials to tooth structure; thus, Er,Cr:YSGG laser decreases microleakage to a greater extent compared to bur ¹⁷.

Table 3: Comparison of marginal microleakage among the three groups

Group	Exact Sig. [2*(1-tailed Sig.)]	
	Occlusal	Gingival
Bur and Er:YAG	0.864	0.165
Bur and Er,Cr:YSGG	0.063	0.971
Er:YAG and Er,Cr:YSGG	0.280	0.315
Bur, Er:YAG and Er,Cr:YSGG	0.166	0.318

Table 4: Comparison of occlusal and gingival microleakage (within group)

Study group	Exact Sig. [2*(1-tailed Sig.)]
	Comparison of occlusal and gingival margins
Bur	0.263
Er:YAG	0.906
Er,Cr:YSGG	0.054

Kohara et al also reported higher microleakage in cavities prepared with high speed bur in accordance with cavities prepared with Er:YAG laser. This different results between our's and their's is due to different materials and methods such as laser parameters, different type of teeth and the most important of them is lack of acid etch usage in their study. Compared to the relatively flat appearance of the mechanical surface prepared with bur and covered with a smear layer, the lased dentin surfaces showed almost no smear layer, and were accompanied with the exposed orifices of dentinal tubules. This can lead to lower microleakage in cavities prepared with laser compared to high speed bur¹⁸⁾.

Bahrololoomi et al.³⁾ reported higher microleakage in cavities prepared with Er:YAG laser compared to high speed bur and attributed this finding to the high ratio of calcium and phosphorus, reduction in ratio of carbonate calcium and subsequent acid resistance of the surface as well as laser ablation, which causes fusion of collagen fibrils and decreases inter-fibrillar space and subsequently reduces resin penetration into these spaces.

Such a controversy in the results of studies may be due to the differences in the design and methodology of studies. Type of teeth, type of restorative materials and laser parameters have been different in our study and the above-mentioned ones.

Many other studies similar to the current study reported a reduction in microleakage in laser group to the level of bur preparation and found no significant difference in microleakage among bur, Er:YAG and Er,Cr:YSGG laser groups^{8, 11, 13, 15, 19-25)}. The following explanation may justify this finding.

Application of laser to dental hard tissue causes a flaky, scaly and irregular surface^{11, 21, 24, 25)} without the smear layer and with open dentinal tubules and intact enamel crystals (prisms). Micro- and macro-scale irregularities are also formed due to tissue ablation by laser and create a suitable surface for bond to composite restorations^{21, 24, 25)}.

A laser-modified dentin layer is formed on lased dentin, which includes an electron dense layer and has wavy areas. Penetration of adhesive resin is thus, limited to this layer due to the fusion of collagen fibrils and absence of inter-fibrillar space¹⁴⁾. Nonetheless, acid etching of laser prepared surfaces can increase surface energy, wettability and roughness and cause chemical and morphological changes in the surface, making it more suitable for bonding^{9, 23)}. On the other hand, bur prepared surfaces are also covered with small pellicles called the smear layer, which needs to be elimi-

nated by acid etching¹⁴⁾. Moreover, etching widens and demineralizes the dentinal tubules and helps the formation of hybrid layer on the surface of primary teeth. Therefore, topographic changes created by laser and acid etching can provide a suitable surface for bonding similar to that created by bur preparation and acid etching^{9, 23)}.

In the current study, occlusal and gingival margins were not significantly different in terms of microleakage. Similarly, Fattah et al,¹⁰⁾ Trellers et al,¹⁴⁾ Borsatto et al,¹²⁾ Baygin et al,⁷⁾ and Ghandehari et al.¹⁵⁾ reported higher microleakage in dentin margins compared to the enamel margins, which was probably due to the high water and organic contents of dentin and its lower surface energy than enamel. Dentin bonding depends on wettability of the surface and consequent mechanical interlocking; thus, smear layer removal and topographic changes in dentin are beneficial and highly important¹⁰⁾. Moreover, bond to dentin is more sensitive than the bond to enamel both technically and substructurally. Bond to enamel is reliable while the bond to dentin is challenging due to high organic content of dentin, variable degrees of mineralization and flow of intratubular fluid towards the outer dentin surface¹⁴⁾. Shafiei et al.¹¹⁾ demonstrated greater microleakage at the enamel margins compared to dentin margins. They attributed this finding to the fact that they used Nanoprimer, which contains acidic copolymer prior to the use of resin modified glass ionomer cement (KN100). Since this acidic copolymer cannot well interact with primary enamel due to its highly mineralized surface, their findings were similar to those of self-etch adhesives. However, the current study, similar to that of Yazici et al,²¹⁾ C et al,¹⁹⁾ Borsatto et al,¹²⁾ and Shafiei et al.¹¹⁾ found no statistically significant difference in microleakage between the occlusal and gingival margins. The results of this study showed that Er:YAG laser with 200 mJ energy, 15 Hz frequency and 3 W power and Er,Cr:YSGG laser with 200 mJ energy, 15 Hz frequency and 3 W power decreased dentin microleakage to the level of enamel microleakage. However, further studies are required on erbium lasers in order to reliably recommend their use for cavity preparation.

Conclusion

1. None of the cavity preparation methods for class V composite restorations completely eliminated microleakage.
2. The lowest microleakage belonged to bur preparation group; although this difference was not statisti-

cally significant.

3. Use of bur, Er:YAG laser and Er,Cr:YSGG laser can all decrease microleakage at the dentin/cementum

References

- 1: DenBesten PK, White JM, Pelino JE, Furnish G, Silveira A, Parkins FM. The safety and effectiveness of an Er: YAG laser for caries removal and cavity preparation in children. *Medical Laser Application*. 2001;16(3):215-22.
- 2: Juntavee A, Juntavee N, Peerapattana J, Nualkaew N, Sutthisawat S. Comparison of Marginal Microleakage of Glass Ionomer Restorations in Primary Molars Prepared by Chemo-mechanical Caries Removal (CMCR), Erbium: Yttrium Aluminum-Garnet (Er:YAG) Laser and Atraumatic Restorative Technique (ART). *International Journal of Clinical Pediatric Dentistry*. 2013;6(2):75-9.
- 3: Bahrololoomi Z, Heydari E. Assessment of Tooth Preparation via Er:YAG Laser and Bur on Microleakage of Dentin Adhesives. *Journal of Dentistry (Tehran, Iran)*. 2014;11(2):172-8.
- 4: Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. *National Journal of Maxillofacial Surgery*. 2012;3(2):124-32.
- 5: Meister J, Franzen R, Forner K, Grebe H, Stanzel S, Lampert F, et al. Influence of the water content in dental enamel and dentin on ablation with erbium YAG and erbium YSGG lasers. *Journal of Biomedical Optics*. 2006;11(3):34030.
- 6: Javadinejad S, Razavi M, Birang R, Atefat M. In vitro study of microleakage of different techniques of surface preparation used in pits and fissures. *Indian journal of dental research: Official Publication of Indian Society for Dental Research*. 2012;23(2):247-50.
- 7: Baygin O, Korkmaz FM, Arslan I. Effects of different types of adhesive systems on the microleakage of compomer restorations in Class V cavities prepared by Er,Cr:YSGG laser in primary teeth. *Dental Materials Journal*. 2012;31(2):206-14.
- 8: Karaarslan ES, Usumez A, Ozturk B, Cebe MA. Effect of cavity preparation techniques and different preheating procedures on microleakage of class V resin restorations. *European Journal of Dentistry*. 2012;6(1):87-94.
- 9: Shahabi S, Ebrahimpour L, Walsh LJ. Microleakage of composite resin restorations in cervical cavities prepared by Er,Cr:YSGG laser radiation. *Australian Dental Journal*. 2008;53(2):172-5.
- 10: Fattah T, Kazemi H, Fekrazad R, Assadian H, Kalhori KA. Er,Cr:YSGG laser influence on microleakage of class V composite resin restorations. *Lasers in Medical Science*. 2013;28(5):1257-62.
- 11: Shafiei F, Memarpour M. Effect of Acid Etching on Long-term Microleakage of Nano Ionomer Restorations in Burand Laser-prepared Cavities in Primary Teeth. *Journal of Dentistry for Children (Chicago, Ill)*. 2015;82(1):3-9.
- 12: Borsatto MC, Corona SA, Chinelatti MA, Ramos RP, de Sa Rocha RA, Pecora JD, et al. Comparison of marginal microleakage of flowable composite restorations in primary molars prepared by high-speed carbide bur, Er:YAG laser, and air abrasion. *Journal of Dentistry for Children (Chicago, Ill)*. 2006;73(2):122-6.
- 13: Moldes VL, Capp CI, Navarro RS, Matos AB, Youssef MN, Cassoni A. In vitro microleakage of composite restorations prepared by Er:YAG/Er,Cr:YSGG lasers and conventional drills associated with two adhesive systems. *The Journal of Adhesive Dentistry*. 2009;11(3):221-9.
- 14: Trelles K, Arnabat J, Espana-Tost T. Microleakage in Class V cavities with self-etching adhesive system and conventional rotatory or laser Er,Cr:YSGG. *Laser Therapy*. 2012;21(4):255-68.
- 15: Ghandehari M, Mighani G, Shahabi S, Chiniforush N, Shirmohammadi Z. Comparison of Microleakage of Glass Ionomer Restoration in Primary Teeth Prepared by Er: YAG Laser and the Conventional Method. *Journal of Dentistry (Tehran, Iran)*. 2012;9(3):215-20.
- 16: Ashwin R AR. comparative evaluation of microleakage of fifth , sixth, and seventh generation dentin bonding agents:an in vitro study. *Journal of Conservative Dentistry: JCD*. 2010;13(3):136-40.
- 17: Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. *Dental materials : Official Publication of The Academy of Dental Materials*. 1999;15(2):128-37.
- 18: Kohara EK, Hossain M, Kimura Y, Matsumoto K, margins to the level of microleakage at the enamel margins.

- Inoue M, Sasa R. Morphological and microleakage studies of the cavities prepared by Er:YAG laser irradiation in primary teeth. *Journal of Clinical Laser Medicine and Surgery*. 20(3), 141-147, 2002
- 19: Korkmaz FM, Baygin O, Tuzuner T, Bagis B, Arslan I. The effect of an erbium, chromium: yttrium-scandium-gallium-garnet laser on the microleakage and bond strength of silorane and micro-hybrid composite restorations. *European Journal of Dentistry*. 2013;7(Suppl 1):S33-40.
- 20: Bahrololoomi Z, Razavi F, Soleymani AA. Comparison of Micro-Leakage from Resin-Modified Glass Ionomer Restorations in Cavities Prepared by Er: YAG (Erbium-Doped Yttrium Aluminum Garnet) Laser and Conventional Method in Primary Teeth. *Journal of Lasers in Medical Sciences*. 2014;5(4):183-7.
- 21: Ruya Yazici ZY, Sible A. Antonson. comparison of Er,Cr:YSGG laser with a chemical vapour deposition bur and conventional techniques for cavity preparation : a microleakage study. *Lasers in Medical Science*. 2010.
- 22: Bertrand MF, Brulat N, Lazzarini V, Marcato G, Namour S, Rocca JP. Er:YAG laser cavity preparation and semi-direct composite resin restoration: a microleakage study. *Photomedicine and Laser Surgery*. 2008;26(5):473-7.
- 23: Rossi RR, Aranha AC, Eduardo CdP, Ferreira LS, Navarro R, Zzell DM. Microleakage of glass ionomer restoration in cavities prepared by Er, Cr: YSGG laser irradiation in primary teeth. *Journal of Dentistry for Children*. 2008;75(2):151-7.
- 24: Yamada Y, Hossain M, Nakamura Y, Murakami Y, Matsumoto K. Microleakage of composite resin restoration in cavities prepared by Er:YAG laser irradiation in primary teeth. *European Journal of Paediatric Dentistry : official journal of European Academy of Paediatric Dentistry*. 2002;3(1):39-45.
- 25: Hossain M, Nakamura Y, Yamada Y, Murakami Y, Matsumoto K. Microleakage of Composite Resin Restoration in Cavities Prepared by Er,Cr:YSGG laser irradiation and etched but cavities in primary teeth. *Journal of Clinical Pediatric Dentistry* 2002;26(3):263-268