S.D.Ü Sağlık Bilimleri Enstitüsü Dergisi
Cilt 3 / Sayı 3 / 2012

ARAŞTIRMA

Farklı enerji yoğunluklarındaki KTP lazer uygulaması sonrası kompozit restorasyonlardaki mikrosızıntı

Microleakage of composite restorations after application of different KTP laser energy densities

Alper Kuştarcı[1], Şeyda Hergüner Siso[2], Neslihan Şimşek[3], Ömer Kırmalı[4]

[1]Department of Endodontics, Faculty of Dentistry, Cumhuriyet University, Sivas, Turkey
[2]Department of Restorative Dentistry, Faculty of Dentistry, Bezmialem University, İstanbul, Turkey
[3]Department of Endodontics, Faculty of Dentistry, İnönü University, Malatya, Turkey
[4]Department of Prosthodontics, Faculty of Dentistry, Akdeniz University, Antalya, Turkey

Abstract

Objectives: The purpose of the present study was to evaluate microleakage in Class V cavities pretreated with different KTP (potassium–titanyl–phosphate) laser energy densities before acid etching application.

Material–Method: Thirty–two human premolars were selected for cavity pretreatment. After Class V cavity restorations in buccal and lingual surfaces, teeth were randomly divided into four groups: Group 1: 1 W, 7.1 J/cm^2 KTP laser, 37% phosphoric acid and Single Bond; Group 2: 1.5 W, 10.7 J/cm^2 KTP laser, 37% phosphoric acid and Single Bond; Group 3: 2 W, 14.2 J/cm^2 KTP laser, 37% phosphoric acid and Single Bond; Group 4: 37% phosphoric acid and Single Bond. The cavities were restored with composite resin. The teeth were then thermocycled for 500 cycles, isolated and immersed in 0.5% basic fuchsin for 24 h. After this period, the teeth were rinsed, dried, and sectioned, and microleakage was assessed by dye penetration at the occlusal and gingival surface of the teeth with stereomicroscope (X6). Data were analyzed with Kruskal–Wallis and Mann–Whitney U tests for independent samples, and Wilcoxon test for dependent samples.

Results: When microleakage at the enamel margins of all groups were compared, no statistical differences were found (p>0.05). There was a statistically significant difference between Groups 3 and 4 (p<0.05) when the scores of microleakage at the cementum margins of the four groups were compared; however, no other groups showed statistically significant differences between them (p>0.05).

Discussions: None of the procedures tested in this study completely eliminated microleakage. KTP laser irradiation prior to acid etching to dentin following cavity preparation reduced mean microleakage values compared with acid etching alone at the enamel and the cementum margins.

Key words: Class V cavity, KTP laser, microleakage

Özet

Amaç: Bu çalışmanın amacı, Sınıf V kavitelerin asitle pürüzlendirilmesi öncesinde uygulanan farklı enerji yoğunluklarındaki KTP (potasyum–titanil–fosfat) lazer ile mikrosızıntıyı değerlendirmektir.

Materyal–Metod: 32 tane premolar diş kavite preparasyonu için seçildi. Bukkal ve lingual yüzeylere Sınıf V kaviteler açıldıktan sonra, dişler rastgele 4 gruba ayrıldı. Grup 1: 1 W, 7,1 J/cm^2 KTP lazer, %37 fosforik asit ve Single Bond; Grup 2: 1,5 W, 10,7J/cm^2 KTP lazer, %37 fosforik asit ve Single Bond; Grup 3: 2 W, 14,2 J/cm^2 KTP lazer, %37 fosforik asit ve Single Bond; Grup 4: %37 fosforik asit ve Single Bond. Bütün kaviteler kompozit rezin ile restore edildi. Dişlere daha sonra 500 kez termal siklus uygulandı ve 24 saat %0,5'lik bazik fuksinde bekletildi. Bu işlemden sonra, dişler yıkandı, kurulandı ve kesildi ve dişlerin oklüzal ve gingival yüzeylerinde boya penetrasyonu ile oluşan mikrosızıntı stereomikroskop altında değerlendirildi (X6). Elde edilen veriler bağımsız örnekler için Kruskal–Wallis ve Mann–Whitney U testi, bağımlı örnekler için ise Wilcoxon testi yapıldı.

Bulgular: Bütün gruplarda mine marjininde oluşan mikrosızıntı değerleri karşılaştırıldığında istatistiksel olarak anlamlı fark bulunmadı (p>0,05). Bütün gruplarda sement marjinindeki mikrosızıntı değerleri karşılaştırıldığında ise, Grup 3 ve Grup 4 arasındaki fark istatistiksel olarak anlamlı bulunurken (p<0,05), diğer gruplar ile arasındaki fark anlamlı bulunmadı (p>0,05).

Tartışma: Bu çalışmada kullanılan yöntemlerin hiçbirisi mikrosızıntıyı önleyemedi. Kavite preperasyonu sonrası asit etching uygulamasından önce KTP lazer uygulaması ile mine ve sement marjinlerinde elde edilen mikrosızıntı değerlerinin, sadece asitle pürüzlendirme sonrası elde edilen değerlere göre azaldığı görüldü.

Anahtar Kelimer: Sınıf V kavite, KTP lazer, mikrosızıntı

Yazışma Adresi/Corresponding: Alper Kuştarcı
Cumhuriyet University, Faculty of Dentistry,
Department of Endodontics, Sivas, Turkey
E–mail: akustarci@hotmail.com
Tel: +903462191010/2764

Müracaat tarihi: 12.09.2012
Kabul tarihi: 03.10.2012

Introduction

Microleakage of oral fluids, fluid components and bacteria can occur at the tooth–restoration interface, causing staining and breakdown at restoration margins, postoperative sensitivity, secondary caries and pulpal reactions. Adherence at the margins of dental restoration is an important factor in the efficiency of dental restorative materials. An intact interface can resist microleakage of bacteria and oral fluids, which is important for prevention of dental pathology and pain (1, 2).

Enamel surface treatment by the acid conditioning technique, first proposed by Buonocore (3), produces microscopic irregularities on the treated surface, increasing enamel area and surface energy, readying it for mechanical retention. Acid–etch is the accepted preparation method for adhesion of composite materials to enamel or dentin; however, it has some disadvantages: it can cause damage to tooth structure (pulp, dentin), clinical manipulation involves drying, wetting, then drying again, removal of the etchant with a syringe can cause damage to adjacent enamel or soft tissues, and treatment times are relatively long (4).

Recently, new innovative methods, such as lasers, have been suggested for creating retention areas for resin bonding (4,5). Since the development of Ruby lasers in the early 1960s, a variety of lasers have been used in dentistry both experimentally and clinically (6). This development in laser dentistry has led to their use in periodontology, preventive dentistry, restorative dentistry, endodontics, minor surgery, orthodontics, and dental laboratories (7). The major laser types in dentistry are: Erbium: yttrium–aluminum–garnet (Er:YAG) laser, Neodymium: yttrium–aluminum–garnet (Nd:YAG) laser, argon laser and carbon dioxide (CO2) laser which have been used for soft tissue surgery and for apical sterilization and partial sealing in endodontic therapy (8,9).

Several characteristics of the lased dentinal tissue have previously been considered advantageous for resin bonding. It was reported that laser energy produces a microscopically rough substrate surface without demineralization, melting, fusion, or sealing of the dentinal tubules by recrystalization of the mineral component of dentine without a smear layer and including dentin surface sterilization (10, 11). Dederich (12) reported a melting effect of laser followed by recrystalization of dentine at the root canal wall when Nd: YAG laser energy was used.

KTP laser emitting at 532 nm, representing a frequency–doubled Nd: YAG device, has been introduced mainly for tooth–bleaching procedures in dentistry and can be delivered through a wide range of constant fibers constant or a pulsed mode. This laser has also been used for other dental applications similar to Nd: YAG laser, including root canal and cavity disinfection, treatment of dentine hypersensitivity, pulp capping, and soft tissue surgery; (13, 14) however, very few reports on KTP lasers have been published in the field of dentistry. Schoop et al. (13) and Kuştarci et al. (14) reported that KTP laser irradiation caused significant reduction of some pathogens. In a previous study, Tewfik et al. (15) reported that KTP laser irradiation led to modest increases in dentinal permeability.

The purpose of the present study was to evaluate microleakage in Class V cavities pretreated with different laser energy densities before 37% phosphoric acid application.

Material–Method

Thirty–two freshly extracted caries–free and restoration–free human premolars were used for this study. The teeth were cleaned of calculus, soft tissue, and other debris and examined under magnification to ensure they were free of fractures and structural defects. Class V cavities (mesio–distal width of 3 mm, occluso–gingival length of 2 mm, and a depth of 1.5 mm) were prepared on buccal and lingual surfaces with a diamond fissure bur (Medin, Czech) in a high–speed handpiece under abundant irrigation. New burs were used after every five preparations. Each preparation was designed with the occlusal margin in enamel and the cervical margin in cementum. No bevels were placed. Thirty–two teeth were randomly divided into 4 groups, with 16 Class V cavities in each group.

Groups 1, 2, and 3 were irradiated at 1 W, 7.1 J/cm^2 (Ton: 10, Toff: 50, emission mode: repeat), 1.5 W, 10.7 J/cm^2 (Ton: 10, Toff: 50, emission mode: repeat), and 2 W, 14.2 J/cm^2 (Ton: 10, Toff: 50, emission mode: repeat) with KTP laser (Smartlite D, Deka, Calenzano Firenze, Italy) energy densities for 40 sec, respectively. Laser beam was delivered by an optical fiber of 200 µm diameter. Group 4 was left without laser treatment as a control. Following the laser application, all surfaces of the cavities were conditioned for 15 sec using 37% phosphoric acid (3M Espe, St. Paul, MN, USA). After washing and drying, two coats of bonding agent (Single Bond, 3M Espe) were applied and light–cured for 20 sec (Hilux, Benlioğlu Dental, Ankara, Turkey). The cavities were restored with composite resin (Filtek Z250, 3M Espe), inserted in three increments. The first two increments were applied obliquely against the occlusal and the gingival walls, respectively. The final increment was inserted flushing the contour of the tooth. Each increment was lightcured for 40 sec with the same visible light–curing unit. The curing light built–in radiometer was used to check for light efficiency before starting each restoration. After immediate finishing and polishing with sequential discs (Sof–Lex Pop–On, 3M Espe), the teeth were stored at room temperature and 100% humidity for 24 h. The specimens were then thermocycled for 500 cycles with baths held between 5ºC and 55ºC, a dwell time of 30 sec, and a transfer time of 3 sec. After thermocycling, the apices of the teeth were sealed with sticky wax and all tooth surfaces except for a zone 1 mm wide around the margins of each restoration, were sealed with nail polish. To minimize dehydration of the restorations, the teeth were replaced in water as soon as the nail polish dried. The teeth were then immersed in a 0.5% basic fuchsine solution for 24 h at room temperature.

After this period, the specimens were rinsed in tap water and each specimen was sliced longitudinally with a a low–speed diamond disc (Isomed Buehler, Ltd, Lake Bluff, IL, USA) with water coolant and evaluated for marginal leakage. The most stained half of the tooth was used to evaluate any microleakage. The degree of dye penetration was then graded at X6 original magnification with a stereomicroscope (SMZ 800, Nikon, USA) using the following scale in a 0–4 scoring system that described the severity of infiltration (Table 1).

Table 1. Scale indicating the degree of leakage

Degree	Leakage
0	no leakage
1	up to 1/3 of the gingival and/or incisal wall
2	up to 2/3 of the gingival and/or incisal wall
3	all gingival and/or incisal wall
4	all gingival and/or incisal wall and axial wall

Statistical analysis

The results of the staining measurements were analyzed with Kruskal–Wallis and Mann–Whitney U tests for independent samples, and Wilcoxon test for dependent samples. All tests were run at a significance level of $p<0.05$.

Results

None of the procedures tested in this study completely eliminated microleakage. The data showing the extent of leakage for the enamel and cementum margins of the restorations are shown in Table 2, Figs. 1 and 2.

Table 2. Distribution of microleakage scores verified at the enamel and cementum margins for the all groups (n=16)

	Enamel scores					Cementum scores				
Groups	0	1	2	3	4	0	1	2	3	4
Groups 1	12	2	1	1	0	7	5	2	2	0
Groups 2	11	3	2	0	0	8	5	1	2	0
Groups 3	13	3	0	0	0	12	3	0	1	0
Groups 4	10	4	0	2	0	6	6	1	1	2

Group 1: 1 W, 7.1 J/cm^2 KTP laser, 37% phosphoric acid, **Group 2:** 1.5 W, 10.7 J/cm^2 KTP laser, 37% phosphoric acid, Group 3: 2 W, 14.2 J/cm^2 KTP laser, 37% phosphoric acid, Group 4: 37% phosphoric acid

Figure. 1. Distribution of microleakage scores for enamel by groups

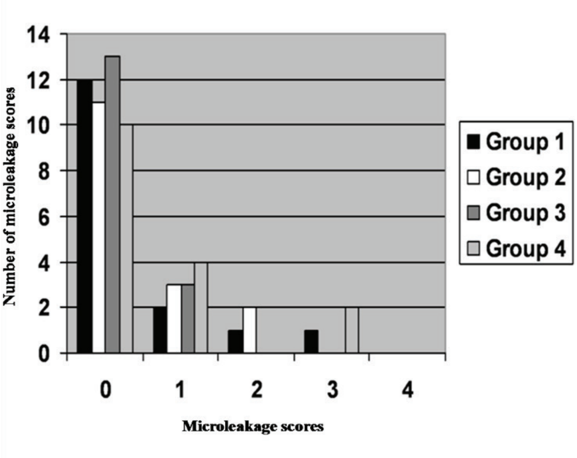
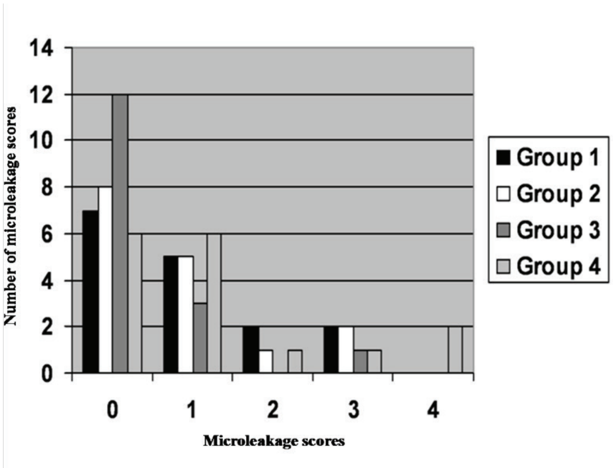


Figure. 2. Distribution of microleakage scores for cementum by groups



When microleakage scores at the cementum margins of the four groups were compared, statistically significant differences were found between groups 3 and 4 ($p<0.05$). There were no significant differences between other groups ($p>0.05$). The lowest mean microleakage values were obtained from group 3 and the highest, from group 4. The mean microleakage values of the other two groups from lower to higher were group 2 and group 1, respectively (Table 3).

When the scores of microleakage at the enamel margins of the four groups were compared, no statistical differences were found between groups ($p>0.05$). The mean microleakage scores of the four groups from lowest to highest were group 3, group 2, group 1 and group 4, respectively (Table 3).

Table 3. Mean microleakage scores of the enamel and cementum margins

	Groups	n	Mean	Std. Deviation
Enamel Margins	Group 1	16	0,44	0.892
	Group 2	16	0,31	0.602
	Group 3	16	0,19	0.403
	Group 4	16	0,63	1.025
Cementum Margins	Group 1	16	0,94	1.063
	Group 2	16	0,81	1.047
	Group 3	16	0,38	0.806
	Group 4	16	1,19	1.377

Group 1: 1 W, 7.1 J/cm^2 KTP laser, 37% phosphoric acid, **Group 2:** 1.5 W, 10.7 J/cm^2 KTP laser, 37% phosphoric acid, **Group 3**: 2 W, 14.2 J/cm^2 KTP laser, 37% phosphoric acid, **Group 4:** 37% phosphoric acid

When the cementum and enamel margins were compared in each group, statistically significant differences existed only in group 1 ($p<0.05$); no significant differences were found in the other groups ($p>0.05$).

Discussion and Conclusion

Microleakage is one of the most important considerations in evaluating restoration success and defined as the passage of bacteria, fluids, chemical substances, molecules, and ions between a tooth and its restoration (16,17). Brannstrom et al. (18), stated that the main biological problem faced in restorative dentistry concerns the favorable environment for microbial growth under restorations. Bacterial activity may result in pulpal sensitivity, pulpal inflammation, secondary caries, and necrosis.

In the present study, the results indicated that in all cases the cementum margins showed higher leakage than enamel margins. These results are similar to other studies indicating that bonding composite resin to enamel results in less microleakage than to dentin/cementum (19–21); this finding can be related to the composition of these two tissues. The thickness of the occlusal surface position enamel allowed for less permability, producing a more resistant surface to dye penetration. However, marginal adaptation becomes even more difficult in Class V cavities where there is little or no enamel at the cervical margins, and the restoration comes in contact with cementum. The surface of the cement is very thin, and the phosphoric acid makes the surface smooth and by extension less retentive (22). Cagidiaco et al. (23) suggested that the leakage observed at cervical margins may be related to the absence of dentine tubules in the limiting 100 µm of the cervical margin.

In the present study, basic fuchsin was used to detect microleakage at gingival and occlusal surface positions. Various methods have been employed to disclose microleakage around restorations. Dye leakage is probably the most common. The principal advantages of this technique are its low cost and ease of application. Disadvantages include subjective evaluation of the results (24) and low molecular weight of the dye, which is less than that of bacteria. Tests using dyes have also sometimes detected leakage where bacteria could not penetrate (25).

In the present study, the microleakage in Class V cavities pretreated with various KTP laser energy densities was evaluated. Because very few reports on KTP lasers have been published, in this paper, KTP laser was compared with Nd:YAG laser especially. Our results indicated that composite sealing was better for teeth treated with KTP laser before acid etching than with acid etching alone. In addition 2 W, 14.2 J/cm^2 KTP laser energy density was found more efficacious than 1 W, 7.1 J/cm^2 and 1.5 W, 10.7 J/cm^2 KTP laser energy densities, but there were no significant differences between groups except for that between 2 W, 14.2 J/cm^2 KTP laser energy density with acid etching and acid etching alone. Obeidi et al. (26) found that the level of microleakage was significantly less in laser–treated cavities than in nonlased cavities. Miserendino et al. (27) reported lower dye permeability of the dentin when the prepared dentin surface was treated with Nd:YAG laser energy. It seems that the deposition of glass–like material seals dentin walls with partial to total closure of dentinal tubules. Gonçalves et al. (28) found that the formation of a substrate constituted of melted hydroxyapatite when laser was used after the application of the adhesive system increases the shear bond strength and consequently reduces marginal leakage. Cooper et al. (29) showed favorable results with the use of laser in their study, obtaining an increase of about 300% in the shear bond strength. However, they used laser prior to the application of an adhesive system. Therefore, we can suggest that the combination of adhesive and laser is promising for the marginal sealing of adhesive restorations.

Our results agree with the trend suggested by Ribeiro et al. (30), who found lower microleakage values with high laser energy densities; however, they found no significant differences between various energy densities. Authors have found significant optical, morphological, and chemical changes in irradiated dental surface. White and Goodis (31) described alterations of the irradiated dentin, such as a decrease in transmission of laser energy, melted and resolidified dentin limited to less than 50 µm in depth, increased roughness of the irradiated surface, and significant alteration of the organic and mineral content of the irradiated dentin. Goodman and Gwinnet (32) compared laser–etched enamel with acid–etched enamel and found that lasers created an enamel surface with cracks, pits, fractures, and craters that lacked sufficient porosity to permit resin penetration. Laser conditioning of the cavosurface raises the possibility that the roughened, irregular surface created by laser treatment may provide mechanical retention for dental restorative materials. However, this may not provide a surface as retentive as a surface treated with conventional acid etching (33, 34). Corpas–Paster et al. (35) and Martinez–Insua et al. (36) reported that the Er:YAG and Nd:YAG laser pretreatment for bonding is unfavorable to adhesion, and that mean tensile bond strength for laser–etched enamel and dentin was significantly lower than for acid–etched. So the additional use of etching after laser preparation is recommended (37). Also, it is of interest to notice that the sealing capability of the lased area did not appear to be changed following the application of 37% phosphoric acid (38).

The application of phosphoric acid etching to the laser–irradiated tooth surface has been reported to have some advantages, decreasing marginal leakage and enhancing bond strength when resin bonding systems are used. When acid etching is performed on a laser irradiated dentin surface before bonding, the phosphoric acid partially removes the highly mineralized peritubular dentin, decalcifies the underlying dentinal structures, and enlarges the dentinal tubule orifices. To create a hybrid layer, the resin must penetrate into collagen fibers and reach the undemineralized dentin surface (37, 38). After acid etching, the surface irregularities are erased, but surface demineralization allows a hybridation process and increased bonding surface at the base of the resin tags. These resin tags form a small part of the bonded surface but penetrate to the depth of the dentin. This situation could positively influence the adhesion of resin and dentin, because the bonding agents could effectively seal the dentinal tubule orifices and produce less microleakage (37).

Within the limitations of this study, the following conclusions may be drawn:

1. None of the procedures tested in this study completely eliminated microleakage.
2. Microleakage scores at the enamel margins of the all groups were compared, no statistical differences were found. When the scores of microleakage at the cementum margins of the four groups were compared, significant differences were found only between groups 3 and 4. There were no statistical differences found between other groups.
3. Comparing the cementum and the enamel margins in each group, no significant differences were exhibited at the all tested groups.

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