Comparison of Microleakage of Class V Composite Restorations in Primary Teeth prepared with Er,Cr:YSGG Laser and High Speed Diamond Bur associated with Three adhesive system

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Research Article

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Abstract

Introduction

: Composite restorations have a high technical sensitivity and a high failure rate of them has been reported. The purposes of this study were to evaluate microleakage of cavity preparation in primary teeth made with an Er;Cr:YSGG and high-speed handpiece rotary, and also compare three types of bonding generations in class V composite resin restoration.

Methods

Ninety freshly extracted sound human primary posterior teeth were used in this study. The teeth were randomly divided into 6 groups with 15 teeth in each. The preparations were performed in groups 1, 2 and 3 with Er;Cr:YSGG laser, in groups 4 ,5 and 6 with a high-speed drill. Dye penetration associated with the occlusal and cervical margins of each restoration was then assessed by stereomicroscope at 40 magnifications. Data were analyzed using Kruskal-Wallis and Mann-Whitney tests at a $P < 0.05$ level of significance.

Results

A higher degree of occlusal and gingival microleakage values was obtained for the group with bur preparation, compared to the group with laser preparation, and there were statistically significant differences in microleakage ($P < 0.05$). There were no statistically significant differences in microleakage of three types of bondings ($P > 0.05$). Overall, microleakage scores of gingival margins were significantly higher than those of occlusal margins ($P < 0.05$).

Conclusion

According to the results of this study, laser preparation of cavity in primary teeth by Er,Cr:YSGG, gives less microleakage of class V composite restorations compared to the conventional methods of bur preparation. There were no significant differences in microleakage of three types of bondings.

What Is Known?

- Longevity of dental restorations was one of the main concerns in dentistry, so interests in lasers have increased.
- Lasers application in dentistry because of minimal bleeding and little pain is so popular than the conventional turbine.

What is new?

- New generations of bonding agents in resin restorative materials have been introduced in order to shorten the chairtime and decrease the technical sensitivity.
- Er,Cr:YSGG laser used in hard and soft tissue in pediatric dentistry, and reduce psychological trauma and fear during the dental visit.

Introduction

Composite restorations have a high technical sensitivity and failure rates. This problem is more serious in pediatric dentistry due to the poor cooperation of children and lack of appropriate isolation. It may lead to the loss of isolation or reduction of bonding durability and increased microleakage of restoration [1, 2]. The choice of dentin bonding agents influences the degree of microleakage observed at dentin margins [3].

Therefore, a successful restoration is dependent on a proper and durable bonding. The type of adhesive system and dental restorative material used, as well as cavity design affect resin bonding strength to dental structure. Nowadays, bonding agents are available in eight generations; however, the fifth generation is used more than the other ones. The sixth generation of bonding agents includes acidic primers and separate resin adhesive.

Nevertheless, the seventh generation is self-etch adhesive system, which consists of etching primer and bonding agents in one component (All in one system). Recently, manufacturers introduced nanofilled dentin adhesive as the eighth generation of bonding agents, known as universal bonding agents. Currently, these agents are the newest type of bonding materials used in dentistry [4].

New researches, unlike conventional bur techniques, emphasize the use of lasers without touching the teeth and any sound or vibration [5, 6]. Previously, CO_2 lasers and neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers were used for soft tissue surgery and cavity preparation. Nonetheless, they had thermal effects on the endodontium; therefore, the erbium family of lasers was introduced [7]

Erbium lasers including erbium- yttrium aluminium garnet laser (Er:YAG [2940 nm]) and erbium, chromium: yttrium, scandium, gallium, garnet (Er,Cr:YSGG [2780 nm]) with many advantages were introduced as alternatives to conventional tools for dental drilling. In this regard, the Er,Cr:YSGG laser was determined as a safe and effective tool for removing dental tissue that is absorbed by water through bonded system (due to its wavelength) and hydroxyapatite crystals [5]

One of the concerns in using lasers to produce a cavity was whether the laser-induced surface changes increase microleakage or reduce in comparison to conventional methods [3]. As mentioned above, in pediatric dentistry, resin restorations require methods to reduce microleakage. Due to the progress of laser in dentistry and its great benefits for children, as well as the growing trend towards using resin materials and the emergence of new bonding systems, in this study we evaluate effect of laser irradiation and new bonding generations on adhering of composite resins in primary tooth cavities in children.

The quality of the margins of composite restorations in terms of leakage is an important issue for clinicians when considering the use of a laser for hard tooth tissue preparation especially in children In order to overcome the problems of microleakage, new generation of bonding agents have been developed including universal bondings. Information regarding microleakage by primary tooth restorations is limited so The aim of this study was to evaluate the microleakage of class V cavities of primary molars prepared by either a conventional dental bur or Er,Cr:YSGG laser and three different adhesive bonding systems.

Materials And Methods

90 freshly and caries-free human primary molars which had to be extracted for orthodontic reasons, ankylosis cause infraocclusion and over retention were used in the present study with no crack, restoration, caries, and abrasion were included in the study. The selected teeth were stored in distilled water for a maximum duration of 3 months until the experiment was carried out. The surfaces of teeth were cleaned with pumice slurry using a rubber cup in a slow-speed handpiece and disinfected prior to the experiment in 0.5% chloramine T solution for 24 hours[8] The samples were randomly assigned into six groups of 15 samples each, as outlined below. A standard class V cavity (4 mm wide, 2 mm high and 2 mm deep) was prepared on the buccal or lingual surfaces of the teeth, with a periodontal probe used during the procedure to measure the preparations. Study groups were:

Group A: The cavities were prepared using an Er,Cr:YSGG laser with no acid etching step. The laser parameters were: wavelength 2780 nm, pulse frequency 20 Hz, sapphire fiber diameter 600 μm, tip to target distance 1 to 2 mm. Gold handpiece and water spray (50% water and 60% air); power of laser was set on 3.25 W. The 6th generation of bonding agent was then applied on cavity surfasce (Clearfil liner Bond, Kuraray Noritake Dental Inc., Japan).

Group B: The cavities were prepared by the laser as in Group A, but Application of 7th generation of bonding agents was carried out (Master-Dent® Ultimate™ SE Bond).

Group C: The cavities were prepared by the laser as in Group A, but applicated with 8th generation of bonding agents (GC Corporation, Tokyo, Japan).

Group D: The cavities were prepared using a sharp diamond straight cylinder (008) bur in an air turbine handpiece (Black Pearl Eco, Bien-Air's Swiss-made) and cooled with air-water spray. The 6th generation of bonding agents was applied on surface cavities.

Group E: The cavities were prepared by the bur as in Group D, but 7th generation of bonding agents was applied on surface cavities.

Group F: The cavities were prepared by the bur as in Group D, but 8th generation of bonding agents was Applied [9, 10]

In all groups there were no acid etching and after application of bonding agents and curing for 20 seconds, cavities were restored with the microhybrid resin composite Filtek Z250 (Filtek, Dental Products, TMZ250, 3m, USA) which was light cured for 40 seconds.

After 24 hours of incubating in distilled water at the temperature of 37°C, the samples were thermocycled for 1000 times between water baths held at 5°C and 500°C. The dwell time was 30 s, and transfer time 10 s [11].

They were then dried superficially, and the apices of the roots embedded with glue wax (Kemedent and Swindon), while the exposed crown and root structure was covered with two coats of nail varnish, leaving a 1 mm window around the cavity margins. The samples were then immersed in 0.5% basic fuchsin (Merck, Germany) for 24 hours, [12–14] rinsed in tap water for 5 minutes and the superficial dye was gently removed.

In addition, to confirm the color of the fuschin, the samples were kept at room temperature for 24 hours; thereafter, All teeth were embedded in autopolymerizing acrylic resin and longitudinally in a bucco-lingual direction sectioned at the center of the class V restorations in order to obtain two halves by a cutting machine (Meccatom, T201A, Presi Co, France) using a double-sided diamond disc at slow speed.

All specimens were evaluated under a stereomicroscope (Olympus, Tokyo, Japan) at 40x magnification and standardized digital images were obtained (Figs. 1–4). The degree of microleakage using dye penetration was scored in a blinded manner using a four-point qualitative scale (Table 1) [15, 16]. It should be noted that the worst scores for occlusal and gingival margins were used for data analysis.

Table 1
Qualitative scale used for dye penetration depth

Dye penetration score	**zero**	**one**	**two**	**three**
Occlusal/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

Ultimately, data analysis was performed using non-parametric test methods, using the Kruskal-Wallis test to analyze the statistical differences in the mean microleakage values among the groups. The Mann–Whitney test was applied to determine significance between experimental groups and to compare the degree of microleakage between the laser and conventional bur preparation method for each restorative material. The selected level of statistical significance was $p < 0.05$.

Results

The frequency of different microleakage degree in all groups is shown in Table 2.

Table 2: Frequency distribution of microleakage in all six groups

Study Group	Microleakage score	0	1	2	3	Total
		Number and percentage	Number and percentage	Number and percentage	Number and percentage	percentage
Group A(laser+6th generation of bonding)	Gingival	7(46.7%)	7(46.7%)	1(6.7%)	0(0.0%)	15(100%)
	occlusal	12(80%)	3(20%)	0(0.0%)	0(0.0%)	15(100%)
Group B(laser+7th generation of bonding)	Gingival	9(60%)	3(20%)	2(13.3%)	1(6.7%)	15(100%)
	occlusal	12(80%)	3(20%)	0(0.0%)	0(0.0%)	15(100%)
Group C(laser+8th generation of bonding)	Gingival	8(53.3%)	6(40%)	0(0.0%)	1(6.7%)	15(100%)
	occlusal	13(%)	2(13.3%)	0(0.0%)	0(0.0%)	15(100%)
Group D(bur+6th generation of bonding)	Gingival	2(13.3%)	10(66.7%)	2(13.3%)	1(6.7%)	15(100%)
	occlusal	5(33.3%)	9(%)	0(0.0%)	1(6.7%)	15(100%)
Group E(bur+7th generation of bonding)	Gingival	0(0.0%)	12(80%)	2(13.3%)	1(6.7%)	15(100%)
	occlusal	1(6.7%)	12(80%)	1(6.7%)	1(6.7%)	15(100%)
Group F(bur+8th generation of bonding)	Gingival	0(0.0%)	9(60%)	2(13.3%)	4(26.7%)	15(100%)
	occlusal	5(33.3%)	8(53.3%)	1(6.7%)	1(6.7%)	15(100%)

In all groups of A, B, and C, the highest frequency was related to the degree (0), and in the other groups was related to the degree (1). Additionally, in the occlusal edges, none of the groups A, B, and C had a microleakage of degree (3). The mean degrees of occlusal and gingival microleakage in all the groups are shown in Table3.

Table 3: The result of Kruskal-Wallis (chi-square) test for comparing the amount of gingival and occlusal marginal microleakage

Occlusal margin	Number	Mean rank	P value
Group A (laser+6th generation of bonding)	15	33	0/001>P
Group B (laser+7th generation of bonding)	15	33	
Group C (laser+8th generation of bonding)	15	30/17	
Group D(bur+6th generation of bonding)	15	54/3	
Group E(bur+7th generation of bonding)	15	66/9	
Group F(bur+8th generation of bonding)	15	55/6	

Gingival margin	Number	Mean rank	P value
Group A (laser+6th generation of bonding)	15	34/8	0/001>P
Group B (laser+7th generation of bonding)	15	34/3	
Group C (laser+8th generation of bonding)	15	33/0	
Group D(bur+6th generation of bonding)	15	51/3	
Group E(bur+7th generation of bonding)	15	56/2	
Group F(bur+8th generation of bonding)	15	63/5	

According to the information shown in this table, the lowest degree of microleakage was in the gingival edge of group C (laser cutting and bonding of 8th generation), and its highest degree belonged to the group F (bur cutting and bonding of 8th generation).

Moreover, the lowest and highest degrees of occlusal microleakage were related to groups C and E, respectively (Table 3). As a result, the group C had the lowest microleakage degree in each occlusal and gingival edge. The results of Kruskal-Wallis test showed that there was a significant difference between the all six groups in terms of occlusal and gingival microleakage degrees ($P<0.001$; Table 3).

However, there was no significant difference in the occlusal and gingival microleakage degree between the types of bonding ($P=0.43$ and $P=0.7$, respectively; Table 4). In the other words, the use of different generations of self-etching bonding did not differ in the reduction of microleakage. The comparison of two groups based on the Mann-Whitney U test showed a significant difference in both occlusal and gingival edges between the laser-prepared and bur-prepared groups(P<0.001) (Table 5). The microleakage degree in groups treated by laser was less than the other groups.

Table 4: The result of Kruskal-Wallis test for comparing the amount of gingival and occlusal marginal microleakage

Occlusal leakage	Number	Mean rank	P value
A and D	30	43/7	
B and E	30	50/0	
C and F	30	42/9	0/43
Gingival leakage	Number	Mean rank	P value
A and D	30	43/1	
B and E	30	45/2	0/7
C and F	30	48/2	

Table 5: The results of Mann-Whitney tests for comparing the groups with each other

Groups	Number	Mean rank	P value
Laser groups	45	32/1	0/001>
Bur groups	45	58/9	

The overall comparison of occlusal and gingival microleakage showed significant difference between them (P<0.001; fig 5). In addition, the amount of gingival microleakage (dentinal margin) was significantly higher than occlusal microleakage (enamel margin).

Discussion

As increasing use of laser technology in dental practice, many studies examined the effects of different types of laser. Cavity preparation by Er,Cr:YSGG laser has many advantages in caries removal in pediatric dentistry. The creation of open dentinal tubules without the presence of a smear layer, which is suitable for the formation of resin tags, is among the benefits of this method [7]

Unlike conventional bur drilling, laser irradiation does not produce any sound and vibration, does not need local anesthesia. In addition, it is less painful to be useful in people with dental anxiety, especially children who are potentially cooperative [6, 14]. The application of resin restoratives is an important challenges which facing in pediatric dentistry. For instance, their high technical sensitivity is one of these challenges.

A successful restoration is dependent on an appropriate isolation, which means the control of moisture, and bleedings at the gingiva margins. This issue has specific problems in pediatric dentistry. Accordingly, choosing a proper bonding system is one of the essential requirements in this field [3]. Generally, washing and drying steps eliminated with using self-etch bonding agents. Therefore, using them saves chairside time, which is important in pediatric dentistry and reduces procedural errors [14]

Composite restoration in primary tooth has In this study, the amount of microleakage of resin restorations was compared between the cavities prepared by Er,Cr:YSGG laser and air turbine dental drilling.

Considering the results of the present study, the use of Er,Cr:YSGG lasers reduced microleakage in the studied groups. It seems that the use of laser causes a slight increase in the temperature of the bonding agent, an enhancement of its penetration, and reduced microleakage [17, 18]

This result was in contradiction with that of Ghandehari's study, which did not show a decrease in the microleakage of the teeth restoration in the primary teeth using Er:YAG laser. This inconsistency might be due to different restorative material used in the class V cavities. Ghandehari et al. used glass ionomer cement for the restoration [19]In addition, Rossi et al., who used glass ionomer cement in class V cavities, did not see any reduction in the marginal microleakage of the cavities prepared by Er,Cr:YSGG laser compared to those prepared by conventional bur [20]

Borsatto and Kohara studied the effect of Er:YAG laser on the marginal microleakage of class V restorations in permanent molars compared to conventional handpiece. Inconsistent with our results, Borsatto utilized flowable composite restorations after acid etching and demonstrated more microleakage in the laser group. This difference might be due to the greater laser ablation, which is stated in the studies below.

Furthermore, regarding the results of the studies conducted by Khan and Niu, there was no significant difference between the marginal microleakage of resin restorations after the preparation of cavity by the Er:YAG laser and bur preparation [21, 22]In the study carried out by Gutknecht et al., high microleakage was observed in the composite restorations of permanent teeth prepared with Er,Cr:YSGG laser without acid etching [23]

However, in line with our results, Kohara restored the cavities with composites without using acid eching, the marginal microleakage in the laser group was significantly higher than the other groups [24, 25] The margins of cavities prepared by laser are irregular, but there is no smear layer, which reduces microleakage.

Furthermore, the findings of Shahabi et al., who showed less marginal microleakage using Er,Cr:YSGG laser in the composite restorations of permanent posterior teeth in comparison with conventional bur cavity preparation was consistent with our result [16]

Self-etch adhesives that have acidic monomers do not need to wash, which simultaneously provide conditioning and priming of the enamel. In this type of bonding, the speed of process increases and its technical sensitivity decreases due to eliminating of rinsing step. It can be useful for resin restoration of primary teeth because by saving chairside time, the probability of losing a child's cooperation diminishes [10]

In this study, three different generations of bonding agents (sixth, seventh, and eighths generations) were used. All of them were self-etch and there was no significant difference in their microleakage without considering the way of cavity preparation.

Baghalian et al. compared microleakage of Er:YAG laser and bur cavities preparation in a primary teeth restored with two kind of self-etch resin adhesive. They observed significantly higher microleakage scores only at the gingival margins for teeth restored with resin composite and one-step self-etch adhesive in the group prepared by laser compared with that of bur preparation. Nonetheless, microleakage scores in both occlusal and gingival margins of the teeth restored with composite and two-step self-etch adhesive, followed by Laser prepared cavity was significantly less than the bur prepared cavity [3]

In our study, both one-step (using 7th and 8th generations of bonding agent) and two-step self-etch bonding (using 6th generation) were applied on primary teeth. However, in all types of bonding, the amount of microleakage in both occlusal and gingival margins of Er,Cr:YSGG laser prepared cavities was less than bur prepared cavities.

Moldes et al compared microlaekage of composite resin performed by Er:YAG / Er,Cr:YSGG lasers and burs associated with two different adhesive systems on permanent teeth. They found that the self-etching adhesive system significantly had a lower microleakage score at dentine margins for cavities prepared by lasers with than the etch-and-rinse two-step adhesive system [26]. In another study Hoseinifar et al. evaluated microleakage of one and two step self-etch adhesive systems in permanent teeth and compare them with the low shrinkage composites in Class V cavities. there were no significant differences in microleakage among two-step and one-step SE adhesive systems on both the occlusal and gingival margins so two-step SE adhesive did not provide better marginal seal than the one-step SE adhesive systems [27].

In the present study, class V cavity, which has a high C factor, was used to evaluate the ability of sealing margins by resin restoration. The other advantage of these cavities was the possibility of simultaneous evaluation of enamel and dentin margins [28]The enamel is highly mineralized and more than 90% of its composition is hydroxyapatite; nevertheless, dentin consists of water and organic matter and a dense network of tubules that run into the pulp.

The adhesion and bond strength to dentin are affected by the remaining dentin thickness and its tubular structure. This tubular structure is not seen in the enamel, which leads to the difference in bond strength in the enamel and dentin. This result confirmed our result, which demonstrated that the amount of microleakage in the gingival margin was more than the occlusal one [29]

Conclusion

According to the results of the present study, the preparation of cavity in the primary teeth by Er,Cr:YSGG laser had a significant effect on the microleakage of class V composite restorations compared to conventional air turbine bur. However, there was no significant difference between adhesive bondings including 6th, 7th and 8th generations in decreasing of microleakage.

Abbreviations

CO2
carbon dioxide
Er,Cr
YSGG:Erbium, chromium-doped yttrium, scandium, gallium and garnet
Er
YAG:Erbium-doped yttrium aluminium garnet laser
Nd
YAG:Neodymium-doped yttrium aluminium garnet

Declarations

Ethics approval and consent to participate: All methods were performed in accordance with Declaration of Helsinki guidelines. This research had been reviewed by the research ethics committee of Hamadan University of Medical Sciences and approved with this special ID: IR.UMSHA.REC.1396.540 and the inform consent was obtained from all subjects guardians because their age was below 16.

Consent for publication: not applicable

Availability of data and materials: All data generated or analyzed during this study are included in this published article.

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Acknowledgments: not applicable

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Figures

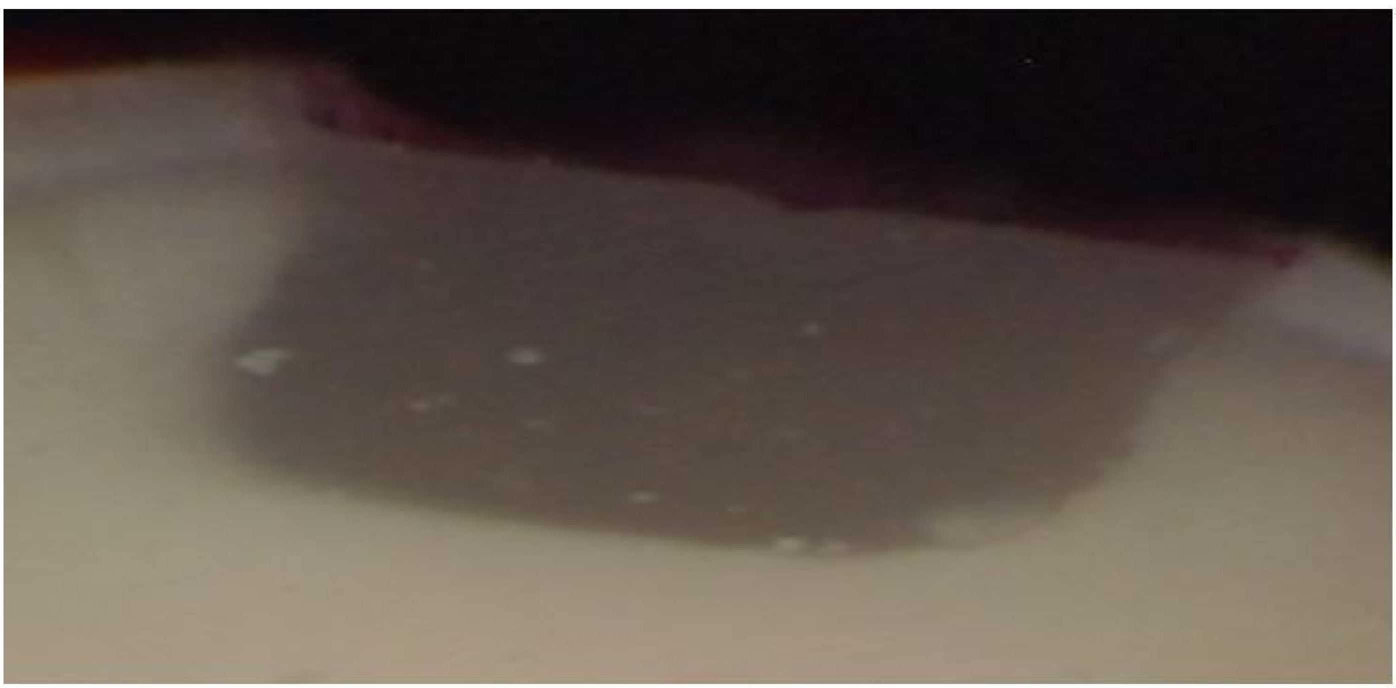

Figure 1

No dye penetration

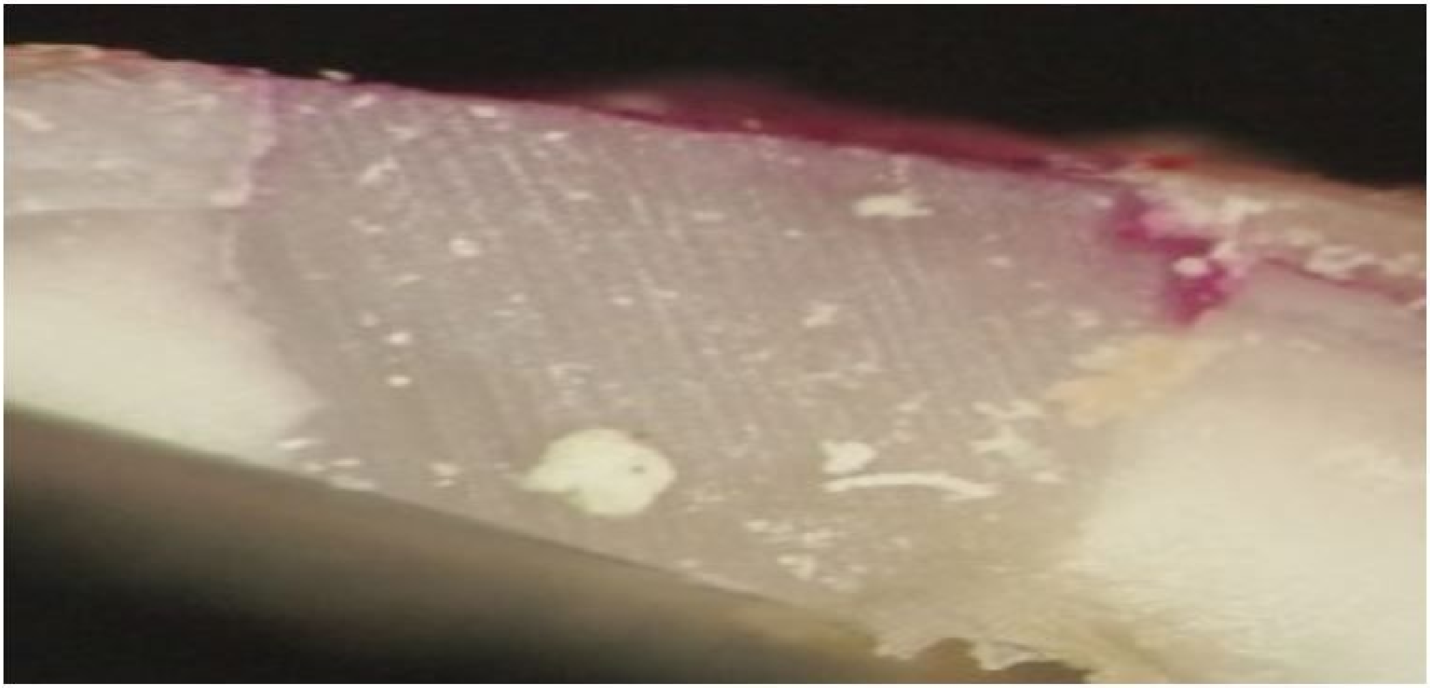

Figure 2

Penetration of dye along the cavity wall, but less than half.

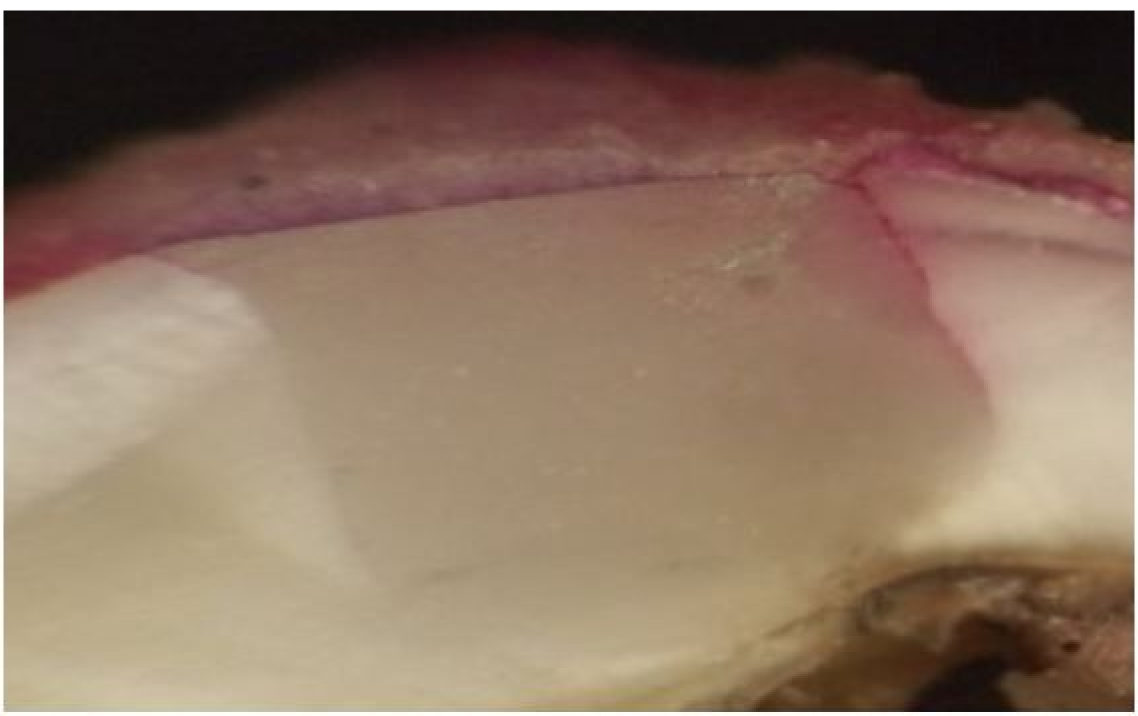

Figure 3

Penetration more than half the distance to the axial wall but not reaching the axial wall.

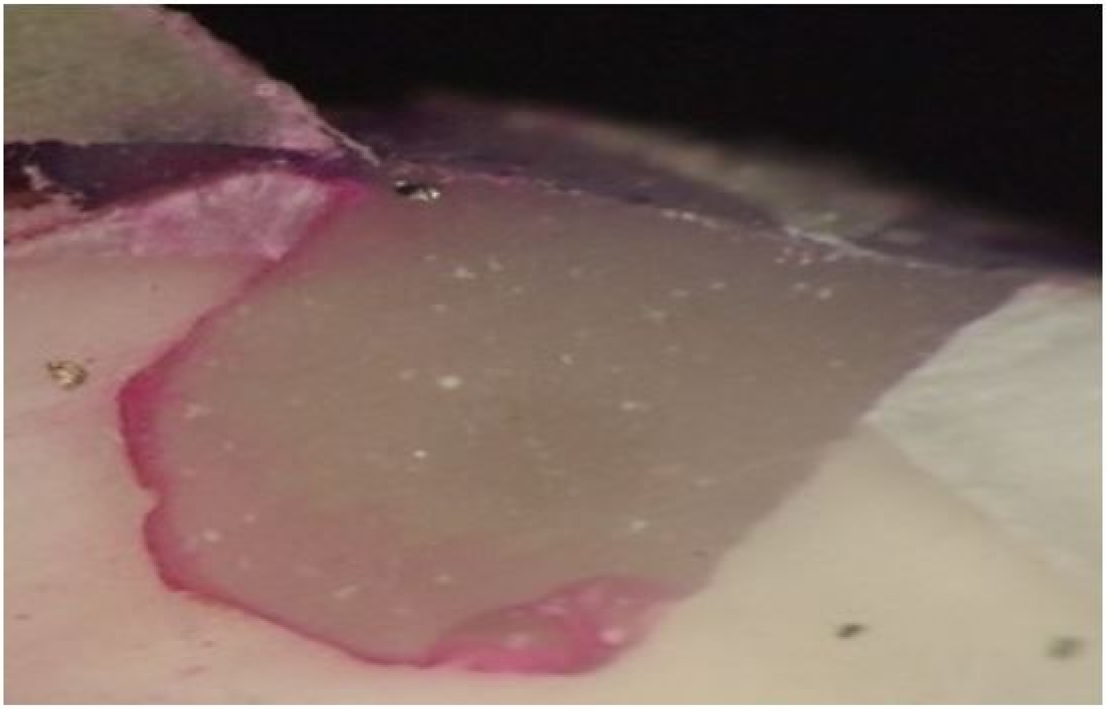

Figure 4

Penetration to the axial wall.

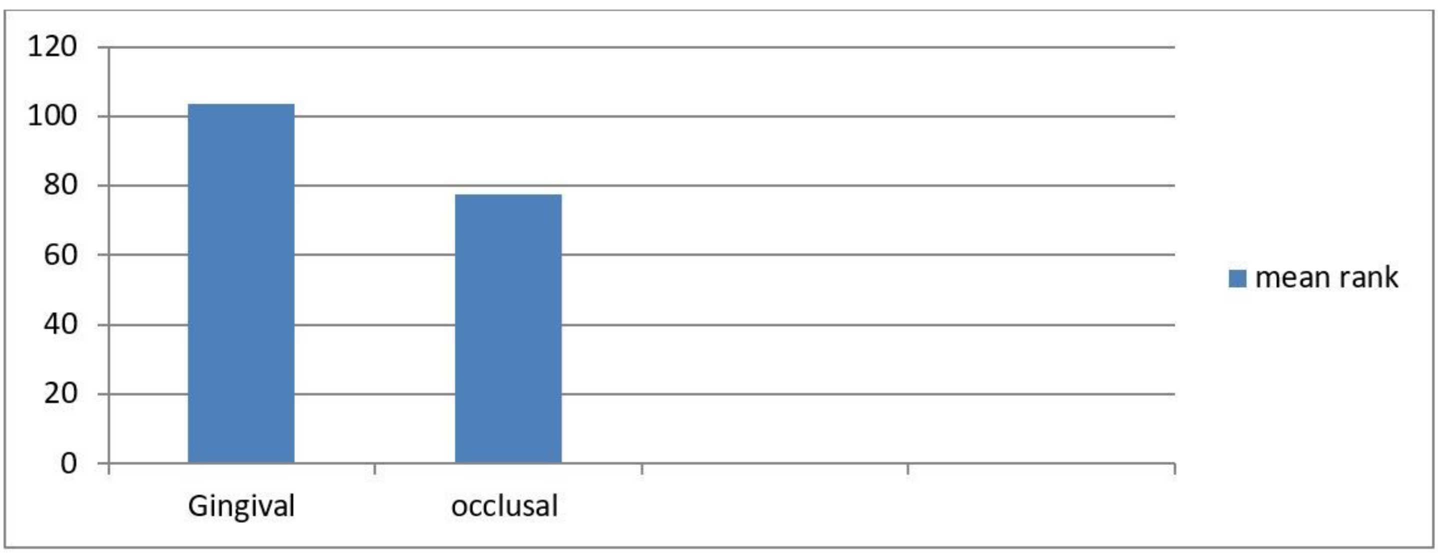

Figure 5

Mean values of microleakage of margins.