Conservative Dentistry

Microleakage of laboratory-fabricated and CAD/CAM composite inlays.

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Изследване степента на микропроницаемост на лабораторни и CAD/CAM композиционни инлеи.

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Summary

Microleakage of indirect restorations in proximal area often occurs at the gingival walls and determinates longevity of restoration.

Aim. *The aim of this study is to compare microleakage of three different methods of composite inlays in the gingival wall.*

Material and methods. *Standardized for inlay MO cavities were cut in 45 extracted human premolars. The gingival margins of all of them were placed in enamel. The prepared teeth were randomly dived in three groups: Group 1 (standard impression technique and laboratory-fabricated inlay), Group 2 (standard impression technique and CAD/CAM inlay) and Group 3 (digital impression and CAD/CAM inlay). All restorations were cemented with self-adhesive dual-curing luting composite. After thermocycling and dye penetration, the teeth were divided into two mesiodistal halves and assessed with stereomicroscope.*

Results. *All of the indirect restorations showed microleakage in the gingival area. Statistical analysis was performed with the Kruskal-Wallis non-parametric analysis of variance test and The Mann-Whitney U-test and Post-hos analyses between the groups. There was a significant difference between groups. Group 1 has shown a significant difference from Group 2 and 3.*

Conclusion. *It can be concluded that there is a significant difference of microleakage between laboratory and CAD/CAM composite inlays. CAD/CAM composite inlays showed better result than laboratory-fabricated ones.*

Key words: *composite inlay, CAD/CAM, microleakage*

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Резюме

Микропросмукването при индиректни обтурации в дистални участъци на съзбието е проблем, засягащ основно гингивалната основа, и определя дълготрайността на възстановяванията.

Цел. *Целта на настоящото изследване е да се сравни микропроницаемостта в гингивалната основа на композиционни инлеи, изработени по три различни метода.*

Материал и методи. *Бяха изработени 45 стандартизирани МО кавитети върху екстрахирани човешки премолари. Границите на гингивалната основа бяха разположени в емайл. Препарираните зъби бяха случайно разпределени в три групи: Група 1 (стандартен отпечатък и лабораторен инлей), Група 2 (стандартен отпечатък и CAD/CAM инлей) и Група 3 (дигитален отпечатък и CAD/CAM инлей). Всички възстановявания бяха циментирани със самоадхезивен двойнополимеризиращ цимент. След термоциклиране и оцветяване, зъбите бяха разделени на две половини и бе оценена степента на микропроницаемост под стереомикроскоп.*

Резултати. *Всички индиректни възстановявания показват микропроницаемост в зоната на гингивалната основа. Статистически анализ на данните бе извършен чрез тест на Kruskal-Wallis и на Mann-Whitney U-test и Post-hos анализ между групите. Има статистически значима разлика между групите. Група 1 показва значима разлика сравнена с Група 2 и 3.*

Заключение. *Съществува статистически значима разлика в стойностите на микропроницаемост между лабораторните и CAD/CAM инлеи. Композиционните CAD/CAM инлеи показват по-добри резултати сравнени с лабораторните.*

Ключови думи: *композиционни инлеи, CAD/CAM, микропроницаемост*

Introduction

Nowadays amalgam restorations are being substituted by modern materials, and the question is which type of material is the best to replace them. Direct composite resin restorations usually are the first choice, but they have several disadvantages like polymerization shrinkage, incomplete polymerization of the material and the toxic effect connecting with this, insufficient hardness and etc.

There is a large variety of composite materials for indirect restoration. They could be divided into two groups: laboratory composites (used by the dental technician for layer-by-layer made constructions) and CAD/CAM blocks, which are milled by a machine. These materials can be called hybrid ceramics, but in fact they are similar to direct composites [1].

The main advantages of the indirect restorations could be summarized as follows: reduced polymerization contraction of the composite resin in the tooth, increased degree of polymerization, reduced porosity and better marginal adaptation, control of contour and contact points. Shrinkage stress should be minimized with this technique, since polymerization occurs before the restoration is cemented and the only material that shrinks is the thin layer of the cement.

One of the very important factors for the longevity of the indirect restoration is the microleakage [2]. In the literature this is determined as movement of bacteria, fluids, molecules, or ions between the wall of the cavity and the material [3]. Clinically microleakage is associated with secondary caries lesion, discoloration, postoperative sensitivity of the tooth, damage of the dental pulp [4; 5]. *In vitro* it could be measured with the use of dye penetration, radioisotopes, bacteria, etc. [6]. The dye methods are one of the most commonly used methods [7].

Today the materials for indirect technique are more often recommended for the restoration of severely damaged vital teeth. Unfortunately there are no sufficient studies on the quality and longevity of the indirect restorations. More studies are necessary to compare the microleakage of laboratory and CAD/CAM composite inlays under standardized conditions.

The aim of this *in vitro* study was to compare the microleakage between composite inlays made with three different techniques. The null hypothesis was that there weren't significant differences between them.

Material and Methods

Tooth selection

Forty-five caries-free human bicuspid teeth, which were recently extracted for orthodontics reasons, were selected. After soft tissue removal, the teeth were stored at 37^{0}C in 0,1% thymol solution for a period of maximum two months.

Cavity preparation

The selected teeth were randomly divided into three groups with 15 teeth each. MO cavities were prepared using a cylindrical diamond bur and air-water spray. The depth and the width of the cavities in the occlusal surface were 2 mm. On the proximal side, the depth and width were 4 mm. The gingival wall was made 1-1.5 mm above the cement-enamel junction. The gingival margin was in the enamel. The divergence of the cavity wall was between 8°-12°. There wasn't any bevelling of the margins.

Inlays fabrication

Group 1

After cavity preparation a two-stage impression was taken using double viscosity A-silicone (Variotime, HeraeusKulzer) in a stock metal tray. The impressions were poured with type IV dental stone (Octarock, HeraeusKulzer). After that the cavities were isolated with isolating gel (Signum insulating gel, HeraeusKulzer). All the laboratory inlays were made with a horizontal layering technique from wall to wall using a composite material (Signum ceramis, HeraeusKulzer). Three layers were adapted for each inlay. Every layer was polymerized for 6 sec and eventually all the layers for 90 sec with a light curing unit (HiLight power 3D, HeraeusKulzer).

Group 2

After cavity preparation a two-stage impression was taken using double viscosity A-silicone (Variotime, HeraeusKulzer) in a stock metal tray. The impressions were poured with type IV dental stone (Octarock, HeraeusKulzer). The surface of the models was scanned (Evolution Zfx, Zimmer Biomet) and a digital model was calculated. Then the restorations were milled with a digital preset spacer for the cement-gap of 50 µm (Zfx in house 5x, Zimmer Biomet).

Group 3

For group 3 after cavity preparation a digital impression was taken using an intraoral scanner (Intra scan Zfx, Zimmer Biomet) and a digital model was calculated. Then the restorations were milled with a digital preset spacer for the cement-gap of 50 µm (Zfx in house 5x, Zimmer Biomet).

Cementation

The inner surface of the inlays was treated with Al_2O_3 50 µm and silanized (Silan, Cerkamed) prior to cementation. The cavity surface was treated with H_2O_2 and alcohol and after that self-adhesive dual cured composite cement (i-Cem, Kulzer) was applied on it. With soft pressure, the inlays were seated completely and after light curing for 1-2 sec the excess cement was removed. The resin composite luting material was finally light cured for 30 seconds from each side.

Leakage testing

After all restorations were completed, the teeth were stored in water at 37°C for 2 weeks and then thermocycled 1000 times at 5°C ± 55°C with a dwell time of 30s and 15s of transfer time for each (method suggested by Yancheva [8]). After that the restorations were sealed and completely coated with a double layer of varnish, except for a 1 mm wide window around the restoration margins, and the root apices were sealed with self-curing two-component temporary crown and bridge material (Prevision Temp, HeraeusKulzer). The teeth were immersed in a methylene blue (0,5%) solution for 12 h. Then they were removed and rinsed with tap water.

The specimens were embedded in self-curing acrylic resin and the restorations were sectioned in mesiodistal direction through the center with Leica SP 1600 microtome. The extent of dye penetration was observed and scored under a stereomicroscope at x40 magnification. Dye penetration at the restoration/tooth interface was scored for cervical margins on a scale from 0 to 4 (n=30):

0 = no microleakage

1 = dye penetration within 1/3 of gingival wall

2 = dye penetration within 2/3 of gingival wall

3 = dye penetration within last (inner) 1/3 of gingival wall up to the axial wall

4 = dye penetration spreading along the axial wall;

All analyses were conducted using SPSS software version 19.0 (SPSS, Inc., Chicago, IL, USA). The Kruskal-Wallis test was used to compare the mean values of the different groups, because of the numbers of specimens. The Mann-Whitney test was used to compare the different groups and identify the groups that differ significantly from the other groups. The Post-hos analysis was used to compare the group and difference between them.

Results

The number of teeth and the percentage of dye penetration for each group are presented in Table 1.

Frequency distribution of the gingival microleakage scores of the different groups are presented in Figure 1 and in Figure 2 shows stereomicroscopic images of the different gingival microleakage scores.

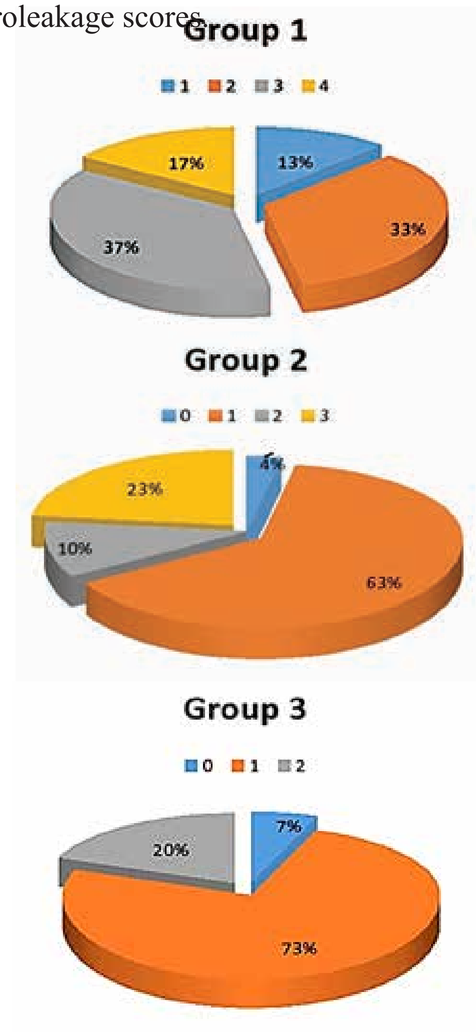

Figure 1. *Frequency distribution of the gingi-*

Table 1. *Microleakage scores distribution for the different groups*

Microleakage scores	Group 1 (n=30)		Group 2 (n=30)		Group 3 (n=30)	
	n	%	n	%	n	%
No microleakage	0	0 %	1	3,33%	2	6, 67
Dye penetration within 1/3 of gingival wall	4	13,33 %	19	63,33 %	22	73,33 %
Dye penetration within 2/3 of gingival wall	10	33,33 %	3	10,00 %	6	20 %
Dye penetration within last (inner) 1/3 of gingival wall up to the axial wall	11	36,67 %	7	23,33 %	0	0 %
Dye penetration spreading along the axial wall	5	16,67 %	0	0 %	0	0 %
KW, $p<0,000001$	$p_{1,2}= 0,0001^a$		$p_{1,3}<0,0001^a$		$P_{2,3}= 0,1159$	
	$t_{1,2}= 3,831$		$t_{1,3}= 5,463$		$t_{2,3}= 1,572$	

a - there is a statistically significant difference (p< 0.05)

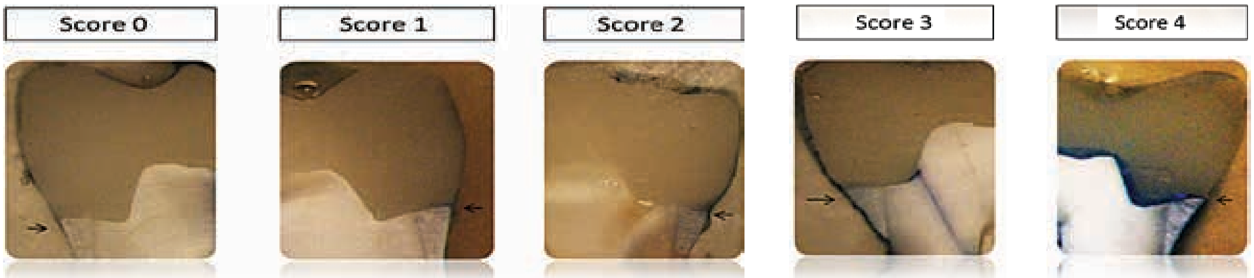

Figure 2. *Representative stereomicroscopic images of the different gingival microleakage scores.*

val microleakage scores of the different groups.

None of the restorative materials tested in this study completely eliminated the microleakage. In Group 1 2/3 of the specimens showed dye penetration between 1/3 of the gingival wall and up to the axial wall. In this group there were no specimens without microleakage. In Group 2 there was no microleakage on the axial wall. 2/3 of the specimens showed dye penetration within 1/3 of the gingival wall. In Group 3 there was no microleakage on the axial wall and the last (inner) 1/3 of gingival wall. 2/3 of the specimens showed dye penetration to 1/3 of the gingival wall similar to Group 2.

Analysis with the Mann-Whitney U test showed significant differences in mean microleakage scores between the three groups. After statistical analyses, it could be concluded that there is significant difference between Group 1 and Group 2, and Group 1 and Group 3. There was no statistically significant difference between Group 2 and 3.

Discussion

In the present study significant differences were found in microleakage between the groups with indirect restorations in laboratory conditions. Group 2 and Group 3 have shown better results than Group 1.

Microleakage studies could use different methods. In this study dye penetration method was chosen because of its simple procedures and the ability to be easily observed by digital imaging. Review of the published literature showed that there have been wide variations in choice of dye used, either as solutions or particle suspensions of different particle size. The concentrations of dye used also ranged between 0,5% -10%, while the time of immersion of specimens in the dye varied between 4 hours to 72 hours or more. In our study we used methylene blue in 0,5 % concentration for 12 h, because of the smallest particles of the molecules in it [9].

The microleakage in the gingival wall is very important for longevity of the restorations, for this reason we investigated only this part of the cavity/tooth interface [10].

In the literature, information comparing microleakage in enamel of laboratory and CAD/CAM inlays is insufficient. In most studies microleakage was compared between indirect and direct restorations. Soares et al [11] reported that the microleakage between indirect and direct restoration is without significant difference when the gingival margin is placed in enamel. In this study, there was significant difference between three groups because of different techniques of impression and fabrication despite of the fact that the gingival margin was again placed in enamel.

Digital impressions have several advantages compared to conventional techniques. One of them is reduction of some of laboratory steps that may cause misfit. Syrek et al conducted an in vivo evaluation to compare the fitness of zirconia crowns produced with digital and conventional impression technique [12]. The first group showed better results. The overall marginal gaps of digital impression were 49 μm and for conventional – 71 μm. Alemeida et al evaluated the marginal and internal fit of CAD/CAM-generated four-unit zirconia fixed dental prostheses made with digital and conventional impressions [13]. There is no statistical difference in marginal fit between two groups, but in the measurement of internal fit, the group of digital impression showed fewer gaps than in the group of conventional technique. Reduction of the marginal and internal fit and the possibility of repeatability are some of the reasons for less microleakage of inlays fabricated with digital impression.

One of the advantages of inlays is their polymerization up to 100% which leads to minimizing shrinkage. Marginal gap between tooth and restoration could be sealed with a thin layer of cement. CAD/CAM inlays have pre-cementation marginal fit. Improvement in digital technology should lead to improvement in the accuracy of inlays and minimize cement`s thickness. As a result of this microleakage should be reduced even more for this type of restoration.

Alaghemand et al showed that CAD/CAM-made restorations had lower cement film thickness than laboratory-made restorations, resulting in a slight decrease in leakage, but there was no significant difference [14]. In our study, results are similar to their results, but there was statistically significant difference between laboratory-made inlays and CAD/CAM-made restorations. One of the reasons could be that reduction of the gap between constructions affects the microleakage. Digital technology could improve the accuracy of the restoration. Experience of the dental technician also could influence accuracy.

In our study microleakage was detected between cement and enamel. Bonding of these two structures is the most important factor for the longevity of constructions. In our study we used light-curing self-adhesive resin based cement. Schlenz and authors [15] reported that for CAD/CAM composite, separate light curing of the adhesive and luting composite is highly recommended [15]. The success of a restoration depends on the long-term sealing ability of the luting materials, which avoids debonding along with microleakage. In this study none of the inlays was debonded.

Another important factor is the type of the cement used. It was reported that the type of cement can influence the microleakage [15]. The cement we used was selected as suitable for composite restorations.

In our study we investigated microleakage in enamel. Further studies are required to investigate microleakage in dentin because of the fact that adhesion with it is more difficult.

Conclusion

Within the limits defined in the experimental design, it can be concluded that there is significant difference of microleakage between laboratory and CAD/CAM composite inlays and the null hypothesis was rejected. CAD/CAM composite inlays have better results than laboratory-fabricated ones and the differences are statistically significant.

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