Original Article / Özgün Araştırma

The Investigation of the Marginal Microleakage of Ceramic Veneer Crowns with Different Finish Lines

Farklı Marjinal Bitim Tiplerinin Seramik Kronların Kenar Sızıntısına Etkisi

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Abstract

Objective: This study aimed to evaluate the microleakage of lithium disilicate and zirconium dioxide all ceramic crowns.

Materials and Methods: A total of 80 premolar teeth with two different marginal finish lines were divided into 2 groups to produce zirconia and lithium disilicate crowns. The crowns were cemented by two different cements (n=10). Samples were stained with 0.5% basic fuchsin solution and the dye penetration was scored. Statistical comparisons were made using two-way ANOVA and two-sample t-test.

Results: There were no statistically significant differences in preparation types ($p>0.05$). However, ceramic systems and cement types for the microleakage test showed significant differences ($p<0.05$).

Conclusion: The use of self-adhesive cement is recommended for lithium disilicate restoration to minimize marginal microleakage.

Keywords
Microleakage, all-ceramic, marginal finish line

Anahtar Kelimeler
Mikrosızıntı, tam seramik, marjinal bitiş çizgisi

Öz

Amaç: Bu çalışmanın amacı lityum disilikat ve zirkonyumdioksit tam seramik kronların mikrosızıntısını değerlendirmektir.

Gereç ve Yöntemler: İki farklı marjinal bitiş çizgisine sahip toplam 80 premolar diş zirkonya ve lityum disilikat kronların üretilmesi için 2 gruba ayrıldı. Kuronlar iki farklı simanla yapıştırıldı (n=10). Örnekler %0,5'lik bazik fuksinde bekletildi ve boya penetrasyonu skorlandı. İki yönlü ANOVA ve iki örneklem t-testi kullanılarak istatistiksel karşılaştırmalar yapıldı.

Bulgular: Preparasyon tipleri arasında istatistiksel olarak anlamlı fark bulunmazken (p>0,05), seramik sistemler ve siman tipleri mikrosızıntı testi için önemli farklılık gösterdi (p<0,05).

Sonuç: Mikrosızıntıyı en aza indirmek için lityum disilikat restorasyonlar için self-adeziv siman kullanılması önerilmektedir.

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Introduction

Microleakage the flow of bacteria, oral fluids, molecules or ions between the restorative material and the dental tissue has a critical impact on the long-term clinical success of all-ceramic restorations (1). Such leakages cause discoloration, cracks, dentin sensitivity and secondary caries formation in the crown area of the restorations in the long run; increased leakage can lead to inflammation and necrosis of the vital pulp, which might necessitate endodontic treatment (2).

Adhesive resin cements impede microleakage by filling the micro-gap between the tooth structure and the restoration (3) however, factors like the polymerization shrinkage, solubility in oral fluids, variable thermal expansion coefficient in different dental tissues of resin cement significantly impact adhesion and hence the amount of microleakage (4). Resin and bonding procedures are as effective as degree of bond between tooth and restoration. For this purpose, the application of acid and primer to the tooth surface strengthens the bond. In self-etch systems, acid and primer application is combined in one step and requires an additional step before cementation (5). Although these systems show high bond strength, they require technical precision. The resin matrix of the cement recently introduced in self-adhesive systems that do not require pre-surface treatment, consists of methacrylate monomers modified with phosphoric acid. Adhesion is dependent on micromechanical retention and chemical interaction between monomeric acidic groups and hydroxyapatite (6). Due to a less mineralized structure of dentin, dentinal fluid flow and tubular structure, bonding is more difficult and requires precision compared to collagen and enamel (7). Another factor affecting microleakage is marginal and internal fit between tooth and restoration. An increase in the marginal gap exposes a larger area of cement to the oral environment, this results in higher cement solubility and ultimately microleakage (8).

This study aimed to evaluate the microleakage of full ceramic restorations produced with different techniques and bonded using two different adhesive systems on teeth with chamfer and rounded shoulder marginal finish designs. The null hypothesis of the study is that different marginal finish design, all-ceramic and adhesive systems will not make a difference in terms of microleakage level of restorations.

Materials and Methods

The ethical approval for this study was acquired from the Selçuk University Faculty of Dentistry Non-Invasive Clinical Research Evaluation Commission (meeting number: 2012/05, date: 03.05.2012). Eighty newly extracted second premolar teeth were used for periodontal and orthodontic purposes. Soft tissue residues and dental calculus on the surfaces of the extracted teeth were cleaned with the help of a periodontal curette, before tooth surfaces were polished. The teeth were kept in distilled water at room temperature throughout the study. Before the preparation, the teeth with their occlusal surfaces on top were embedded in acrylic, 2 mm below the enamel-cement junction line in molds with a diameter of 2x2x2 cm, and the samples were randomly divided into 8 groups (n=10). All teeth were prepared using a lathe with a reduction of 2 mm from the incisal edges, 1 mm from the palatal surfaces, 1.2 mm from the vestibule and approximal surfaces, and a taper angle of 12°. Half of the samples were prepared with a 135° angled chamfer and the other half with a rounded shoulder end design with a step thickness of 1 mm.

After the preparation of the 2^{nd} upper premolar teeth, impressions were taken using polyvinyl siloxane impression material (Zetaplus putty, Oranwash L light hydrocompatible, C-silicone, Zhermack Clinical Badia Polesine, Italy). Samples were placed in the mold with finger pressure using a one-stage impression technique. Type IV dental hard plaster (GC Fujirock EP, GC Europe N.V, Leuven, Norway) was poured into the impressions and left for an hour to solidify. The samples obtained were divided into two groups for the construction of two different ceramic restorations (n=40).

Preparation of IPS Empress eMax Press Ceramic Samples

Using a die spacer thin brush (Megadental GmbH Büdingen, Germany), plaster day materials were applied to the walls of the working models to obtain 2 coats with a 15 μ thickness. To prepare the restorations, modeling was made from wax (Bego, Bremer Goldschlägerei Bremen, Germany) developed for eMax Press. Baking and pressing process were done according to the manufacturer's instructions. The samples were sandblasted with 50 μ Al_2O_3 particles at 2 millibar pressure and cleaned in an ultrasonic cleaner for 10 minutes. Each ceramic substructure was placed on the die and eMax Ceram (Ivoclar Vivadent AG, Schaan, Liechtenstein) ceramic was applied to give the upper 2^{nd} premolar tooth form and fired. The prepared IPS Empress eMax all ceramic crowns were placed on the cut teeth and their marginal integrity and harmony were checked, and the final glaze layer was applied and fired.

Preparation of Zirkonzahn Specimens

Imaging spray (White Peak Systems GmbH&CO. KG Langeheide, German) was sprayed evenly all over the samples. After, the plaster model was fixed on the scanner's table and images were taken with the scanner. On the digital impression obtained, the marginal limits of the restoration were determined with the help of a computer and digital designs were created. The milling process was carried out by transferring the obtained data to the milling unit (Yenamak, İstanbul, Turkey). Samples were treated with 50 μ Al_2O_3 for 15 seconds and sandblasted under 2 bar pressure over time.

Cementation of Specimens

Multilink N (Ivoclar Vivadent AG, Schaan, Liechtenstein) and RelyX U200 (3M-ESPE, USA) resin cements were used for the cementation of IPS Empress eMax, and Zirkonzahn restorations.

The inner surfaces of IPS Empress eMax restorations were treated with hydrofluoric acid (IPS Ceramic Etching Gel, Ivoclar Vivadent, Schaan, Liechtenstein) for 20 s. After washing restorations for 30 s with water and dried, RelyX and Multilink N cements were applied to all samples according to manufacturer's instructions. Then, the samples were placed in a universal testing machine (Elista Co, İstanbul, Turkey) under constant pressure and polymerized with LED (450 mW/cm^2) light device (Bluephase, Ivoclar Vivadent, Schaan) for 40 s under a constant load of 30 N., Liechtenstein). The materials used are given in the Table 1.

Thermal Cycle Application and Staining of Samples

All samples were kept in distilled water at 37 °C for 24 hours and placed in the Thermal Cycler Tester (Dental Technic, Konya, Turkey) and treated with 5000 thermal cycles for 30 sat +5 °C and +55 °C. The samples were placed in 0.5% basic fuchsin solution in groups with their crowns down and in this way they were kept in an oven at 37 °C for 24 h. The samples extracted from the basic fuchsin solution were washed under running water until all the dye was removed. To cut the crown, the long axis of the crown was perpendicular to the ground plane at a low speed, under the water cutting device (Buehler Isomet 1000 Low Speed Saw, Buehler Ltd, Lake Bluff, IL, USA) was placed. Each tooth was divided in the bucco-lingual and mesio-distal directions into 4. The roots of the teeth were cut 2 mm below the crown margin, perpendicular to the long axis of the tooth, under water cooling. A total of 8 measuring surfaces were obtained from each sample. The surfaces of all sections to be measured were polished with 600, 800 and 1200 numbered sandpaper respectively. Dye penetration amounts in the sections were examined under a stereomicroscope (Olympus, SZ-PT, Japan) at x20 magnification. Mean of 8 measurement values obtained from each sample was taken.

Microleakage assessment was made according to the following scoring;

0= no leakage

1= leakage extending 1/3 of the margin

2= leakage extending 2/3 of the margin

3= leakage entire

4= leakage extending more than 1/3 of the axial wall

Table 1. Materials used in the study

Material type	Commercial name	Lot	Manufacturer	Type
Resin cement	Multilink N	R05845	Ivoclar Vivadent AG, Schaan, Liechtenstein	Sef-etch cement
Resin cement	RelyX U200	505225	3M ESPE Deutschland, Germany	Self-adhesive cement
Pressable ceramic	IPS Empress eMax press	R54294	Ivoclar Vivadent AG, Schaan, Liechtenstein	Lithium disilicate
CAD/CAM ceramic	ICE Zirkon	ZA9192A	Zirkonzahn GmBh, Bruneck, Italy	Zirconium dioxide
Acid-etch	IPS etching gel	R48184	Ivoclar Vivadent, Schaan, Liechtenstein	Hydrofluoric acid

CAD/CAM: Computer-aided design/computer-aided manufacturing

5= leakage extending more than 2/3 of the axial wall

6= leakage extending on the entire axial wall, including the incisal edge

7= leakage beyond the incisal edge (9).

Statistical Analysis

Statistical analysis of the microleakage results obtained in our study was performed in SPSS (Windows, SPSS 17.0) package program. Two-way analysis of variance was used to determine whether there was an interaction between the preparation, cement and porcelain factors. Independent two-sample t-test was used for pairwise comparisons between the factors with a difference.

Results

According to the two-way ANOVA, there are significant differences in cement and porcelain types (p<0.05) but there was no difference in their interactions (p>0.05). Results of two independent sample t-tests (Table 2) showed that among the same full ceramic system and the same cement type groups, the step type did not make a statistically significant difference on microleakage (p>0.05). Although shoulder samples presented lower microleakage values than chamfer samples, there was no significant difference between the two groups (p>0.05). The highest dye penetration in all groups is the score of 3. The lowest dye penetration scores were in the Empress-Shoulder-RelyX group and the highest micro-free scores were seen in the Zircon-Chamfer-Multilink group. In the Empress-Shoulder-RelyX group, there was no dye penetration in 41 sections, while score 1 in 35 sections and score 2 in 4 sections were seen score 2. In the Zircon-Chamfer-Multilink group, dye penetration in 5 sections was not seen, while the score 3-level was observed in 8 sections. The highest score was found at 2 levels in all groups. Microlekage score in specimens are given Table 3.

Table 2. Result of the ındependent two-sample t-test

	Variant	Mean	SD	p-value
Ceramic	IPS Empress Zirkonzahn	0.893 1.099	0.061 0.076	0.038
Cement	RelyX Multilink	0.615 1.377	0.024 0.046	0.002
Preparation	Chamfer Shoulder	1.039 0.952	0.067 0.074	0.385

SD: Standard deviation

Among the same full ceramic system and the same step type groups, it was found that the type of cement used had a significant effect on the microleakage (p<0.01). RelyX had lower microleakage values in all groups than Multilink cement. Similarly, Empress restorations in all groups exhibited lower microleakage values than zirkonzahn restorations (p<0.05). Mean, minimum, maximum and standard deviation value for each group presented Table 4.

Discussion

This study evaluated the microleakage scores of zirconia and lithium disilicate crowns fabricated on natural teeth, self-adhesive and self-etch cements as well as marginal finish design. The hypothesis was partially rejected because the all-ceramic systems used in the construction of the restorations and the adhesive systems used in the cementation affected the microleakage scores. The part of the hypothesis related to the marginal finish design was accepted. It was observed that the marginal preparation design did not affect the microleakage level.

Table 3. Microleakage scores in specimens

Group	n (section)	0	1	2	3
Empress-Shoulder-Multilink	80	15	38	25	2
Empress-Shoulder-RelyX	80	41	35	4	-
Zirkon-Chamfer-Multilink	80	5	31	36	8
Zirkon-Chamfer-RelyX	80	33	36	11	-
Empress-Chamfer-RelyX	80	38	38	4	-
Empress-Chamfer-Multilink	80	12	36	30	2
Zirkon-Shoulder-Multilink	80	7	33	34	6
Zirkon-Shoulder-RelyX	80	35	38	7	-

Table 4. Mean, minimum, maximum and standart deviation value for each group

Group	n	Mean	Min.	Max.	SD
Empress-Shoulder-Multilink	10	1.177	0.88	1.5	0.0651
Empress-Shoulder-RelyX	10	0.527	0.38	0.75	0.0361
Zirkon-Chamfer-Multilink	10	1.59	1.13	2	0.0873
Zirkon-Chamfer-RelyX	10	0.702	0.5	1.0	0.0562
Empress-Chamfer-RelyX	10	0.577	0.5	0.88	0.0388
Empress-Chamfer-Multilink	10	1.29	0.88	1.63	0.0746
Zirkon-Shoulder-Multilink	10	1.452	1.0	1.88	0.09
Zirkon-Shoulder-RelyX	10	0.653	0.5	1.0	0.0447
Total	80	0.996	0.38	2.0	0.05

Min.: Minimum, Max.: Maximum, SD: Standard deviation

There are studies evaluating this relationship based on the low level of microleakage at the crown-cement interface associated with the small marginal gap (10). Asavapanumas and Leevailoj (11) examined the marginal fit of IPS eMax, Cercon and Lava systems and found the best fit values in the Cercon group and the highest mismatch values in the Lava group. Use of optical scanner in Lava system over use of laser scanner in Cercon system creates a difference which may affect marginal compliance. Mou et al. (12) indicated that the triangular region between the axial wall and the margin cannot be scanned by the camera in the posterior region due to the angulation of the camera in the intraoral scan, and this would negatively affect the marginal alignment. They reported this as the 'distal shadow' phenomenon. Despite advances in computer-aided design/computer-aided manufacturing (CAD/CAM) technology, software and hardware limitations during restoration design adversely affect marginal fit, and access to the incisal and inner regions may be limited during the milling phase. The eMax Press technique is comprised of fewer steps compared to CAD/CAM systems, and the compatibility of the restoration is more related to the technician's sensitivity and experience. Lower microleakage values of the eMax Press in our study is believed to be from the marginal accuracy of the restorations. Pressable ceramics are based on the preparation of a wax sample directly on the die model obtained from the prepared tooth. Since the pressing is done under pressure and vacuum in the molten porcelain ingot, the details, especially on the margins, are accurately obtained. Shrinkage occurs at a very low rate (0.2%) since the thermal shrinkage of the restoration is compensated by the soft porcelain mass in the casting cone during cooling after pressing, and the thermal expansion of the special investment used (13). In this way, restorations with dimensional stability are obtained.

Chamfer and rounded shoulder finish lines are highly recommended for all-ceramic restorations; however, there is no consensus on which design is better. There are different results from studies evaluating marginal fit which may be due to differences in margin preparation style and restoration materials (14). Komine et al. (15) evaluated the effect of shoulder, rounded shoulder and chamfer preparation on internal compliance in zirconium dioxide-based restorations and reported that internal compliance was significantly lower in shoulder ending design. In our study, rounded shoulder and chamfer design were applied; and even though microleakage values were found to be lower in the samples with rounded shoulder group, no significant difference was found between the two. In the rounded shoulder marginal design, defects and openings in the marginal region can be determined more easily than in the chamfer marginal design, accordingly the marginal gap can be reduced and the microleakage level can be minimized (16).

Resin and bonding procedures are as effective as the degree of bond between tooth and restoration. Application of acid and primer to the tooth surface can strengthen the bond. In self-etch systems, acid and primer application care can be combined in one step and requires an additional step before cementation (5). In order to reduce these steps that require clinical sensitivity, self-adhesive systems have been developed; they can simultaneously demineralize enamel and dentin thanks to the acidic nature of phosphoric methacrylates in functional monomer components. In this way, micromechanical bonding takes place (17). Chemical bonding also occurs as a result of the reaction of phosphate groups in the functional monomer composition and hydroxyapatite in dental hard tissues (18). In our study, RelyX cement also showed lower microleakage values than Multilink N. The multifunctional orthophosphoric acid methacrylates in RelyX cement are believed to interact with the tooth surface and provide an effective seal. This result may be due to the less acidification of the tooth surface by Multilink and a weaker resin infiltration and hybrid layer formation. In addition to the complex structures formed by calcium ions, it is accepted that various physical interactions such as hydrogen bonds or dipole-dipole bonds are effective in self-adhesion (19).

Conclusion

This study demonstrates that ceramic restorations containing lithium disilicate have lower microleakage than zirconia restorations. Self-adhesive cements may be preferred in restorations over self-etch resin cements to reduce microleakage. For clinical application in the marginal design selection both rounded shoulder and chamfer types can be recommended.

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Ethics

Ethics Committee Approval: The ethical approval for this study was acquired from the Selçuk University Faculty of Dentistry Non-invasive Clinical Research Evaluation Commission (meeting number: 2012/05, date: 03.05.2012).

Informed Consent: Informed consent is not required.

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Authorship Contributions

Surgical and Medical Practices: C.A., Consept: Ö.İ., Design: Ö.İ., Data Collection or Processing: C.A., Analysis or Interpretation: C.A., Literature Search: C.A., Writing: C.A.

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