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Evaluation of Marginal Adaptation and Microleakage of Differant All-Ceramic Porcelain Systems

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Research Article

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ABSTRACT

Purpose: This study evaluated the marginal adaptation and microleakage of the In-Ceram Alumina, In-Ceram Zirconia and Finesse press all-ceramic porcelain systems.
Material and methods: Thirty maxillary central teeth extracted for periodontal reasons without caries and cracks were divided equally into three groups and there was no control group; only the three systems were compared. Sample teeth cemented were stored in distile water for 24 hours. Then, they were applied to a repeated thermal cycle for 500 times. The samples were left in 5% of basic fuchsin dye for 24 hours. For the marginal adaptation rankings, all of the sample teeth for which cross-sections were made were moved into the metal microscope (Scherr Turico St. James/Minn./USA) and the marginal adaptation degrees were measured in both the palatinal and vestibul regions by measuring twice with x10 enlargement at micron level. For the statistical evaluations of marginal adaptation and microleakage values, Kruskal Wallis test has been used.
Results: The differences between the three all-ceramic porcelain systems are not significant. The Finesse porcelain system caused the least leakage in both regions. In second place in both regions was In-Ceram Alumina. In-Ceram Zirconia caused the most leakage in bothregions. The biggest magrin gap in the palatal region was seen in the Finesse porcelain system, In-Ceram Zirconia in second place. Theleast marginal gap was caused by the In-Ceram Alumina porcelain system.
Conclusions: When the microleakage scores of the In-Ceram Alumina, In-Cream Zirconia and Finesse groups are compared, the differences between the groups are not significant. When the marginal adaptation values of the In-Ceram Alumina, In-Ceram Zirconia and Finesse groups are compared in terms of palatal and vestibular values, the differences are not statistically significant.

Key words: Marginal adaptation, Microleakage, All-Ceramic Porcelain Systems.

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Introduction

New ceramic materials for restorative dentistry have been developed and introduced in recent years.[1] Dental ceramics are known for their natural appearence and their durable cemical and optical properties. However, dentists have remained suspicious of marginal adaptation and microleakage of ceramic restorations.[2]

Along with physical properties of the materials and esthetics of the defınitive restoration, a critical clinical parameter is the quality of adaptation to the prepared tooth. Marginal adaptation is one of the important criterions used in the clinical evaluation of fixed restorations. The presence of marginal discrepancies in the restoration exposes the luting agent to the oral environment. The larger the marginal discrepancy and subsequent exposure of the dental luting agent to oral fluids, the more rapid is the rate of the cement dissolution. The resultant microleakage permits the percolation of food, oral debris, and other substances that are potential irritants to the vital pulp. The longevity of the tooth could be compromised, not only by caries, but also by periodontal disease. Clinical studies have shown that poor marginal adaptation of a restoration correlates with increased plaque retention and reduced gingival health, as indicated by a higher Plaque Index (PI), an elevated Gingival Index (GI), and increased Pocket Depth (PD). A change in the subgingival microflora is also attributed to inadequate marginal adaptation.[4] Inaccurate margins can lead to changes in the periodontal tissues and/or to recurrent caries, and so it is important to assess the accuracy of margins resulting from the use of new, improved materials or techniques[5], however, the adaptation of complete ceramic crowns is a matter of concern to the dentist despite the manufacturer's claim of their superior adaptation.[6]

All-ceramic dental restorations provide esthetics seldom revealed by metal-ceramic restorations. One all-ceramic System is fabricated using a slip-cast technique (In-Ceram, Vita/Zahnfabrik, Bad Säckingen, Germany) and another by a heat-press technique (Finesse, Ceramco, Burlington, NJ, Germany)[4] Alumina ceramic (In-Ceram, Vita/Zahnfabrik, Bad Säckingen, Germany) was recently introduced to create all-ceramic substructures for individual crowns and fixed partial dentures. This ceramic materiai, known originally as Slip-cast, was developed in 1985 by Dr. Sadoun of the biomaterials research laboratory at the University of Paris.[7]

The aim of this study evaluates the marginal adaptation and microteakage values of three all- ceramic porcelain systems.

Materials and Methods

The marginal adaptation and microleakage of 3 different all-ceramic porcelain systems were examined: In-Cream Alumina (In-ceram Alumina, Vita/Zahnfabrik, Bad Säckingen, Germany), In-cream Zirconia (In-ceram Zirconia, Vita/Zahnfabrik, Bad Säckingen, Germany) and Finesse (Finesse, Ceramco, Burlington, NJ, Germany). Thirty maxillary central teethextracted for periodontal reasons without decay and cracks, were used. Teeth were divided equally into three test groups (In-Cream Alumina ten exams (n=10), In-cream Zirconia ten exams (n=10), Finesse ten exams (n=10). The teeth were placed into an autopolymerizing acrylic resin mold for preparation processes for adaptation to the parallelometer table.

The teeth were cut so as to form a 90 degree shoulder in the marginal region with a reduction of 1.2 mm -1.5 mm from the facial, 1.5-2 mm from the incisal, 1.2-1.5 mm from the lingual and interproximal surfaces using a grooved diamond bur (Z-Rex, Diatec Dental AG, Heerbrugg, Germany) and the parellelometer (Parallelometer, Marathom M103, Murcia, İspanya) was externally cooled with an injector, and thus the tooth preparations were performed.

Preparation of In-Cream Alumina and In-Cream Zirconia Porceiain System Samples According to the manufacturer's instructions, the In-Cream Alumina and In-Cream Zirconia processes were made using the same impression materials and the putty-wash technique, after tooth preparation.

To form the casts, phosphate bonded revetment (In-cream Spezialgips revetment, Vita/Zahnfabrik, Bad Säckingen, Germany) was used by mixing 20 g of revetment with 4.6 g of water in revetment mixing. However, before the preparation procedure, servicalregions on the teeth of the cast were determined and the die spacer material (Die spacer Versiegler, Vita/Zahnfabrik, Bad Säckingen, Germany) was applied according to the manufacturer's instructions, over the teeth on the cast, by forming 30-50 microns of cement space in order to make it easier to work. For the In-Ceram Alumina, alumina porcelain powder and for the In-Ceram Zirconium, zirconium porcelain powder were mixed with a glass spatula in a glass tube and then the mixing procedure was completed in a VıtasonicII (VıtasonicII, Vita/ Zahnfabrik, Bad Säckingen, Germany) device for 5-10 minutes according to the manufacturer's instructions.

Then the mixture obtained was moved from the glass tube into a plastic one. The porcelain powder and liquid mixture made as if performing wax modeling over the cast with dies previously made were applied in the form of coatings using a number 5 sable brushes (Vident brushes, Vita/Zahnfabrik, Bad Säckingen, Germany) and the initial conditions of the teeth forms started to be processed. Fore each coating, the same processes were applied. Following the coating process, the overflowed sections were corrected with respect to their form using a number 15 lancet.

The In-Ceram Alumina and In-Ceram Zirconia porcelain samples over the casts with dies were put into an oven manufactured by the same firm (Inceremat, Vita/Zahnfabrik, Bad Säckingen, Germany). The samples were kept for 6 hours at 120 °C with an 8.33 °C increase per minute. They were kept there for another 2 hours and then for a further 2 hours at 1120 °C, and thus the samples were made.

The temperature of the öven was 200°C for 30 minutes for In-Ceram Alumina porcelain samples and after 2.5 hours it reached 1110°C. The oven was at 200 °C for 50 minutes for In-Ceram Zirconia porcelain samples and after 2.5 hours it reached 1140°C. When the temperature reached 400°C, the oven was opened and left to cool to room temperature. Diamond burs were used to level samples removed from the oven, and under 6 atmospheres pressure, they were subjected to 30-50 microns aluminum oxide sanding. The samples were then placed into the oven on the oxide program at 960°C for 10 minutes to discharge the excess glass.

The porcelain (Vitadur Alpha porcelain set, Vita/Zahnfabrik, Bad Säckingen, Germany) was applied with the coating technique after the last leveling process, according to the manufacturer's instructions, and then the glazing material was applied. Following 4 minute preheating, the oven, kept at 600°C with a 107°C increase over 3 minutes immediately after the preheating, was raised to 920°C and the porcelain samples waiting for 1 minute at this temperature were subjected to 5 minute-cooling and were taken from the oven, thus the glazing process was completed.

Preparation of Finesse Porcelain System Samples, According to the manufacturer's instructions, the Finesse process was made using the same impression materials and the putty-wash technique, after tooth preparation.

In order to prepare porcelain samples of Finesse with heat pressure technique, the necessary wax samples were made by melting and pouring the wax into the mold. The wax samples were made according to the manufacturer's instructions by using refractory die material from the same manufacturer. It was mixed in the revetment mixing machine and sprued into the cylinder plastic casting path and was taken into the investment ring. Then, these rings were placed first into the pre-heating oven and with the rise of 5°C per minute and heated until the temperature reached 850°C and wax removal process was made for 60 minutes.

Without keeping the investment rings waiting, they were moved into the oven and placed into the manchet anchorage. According to the baking conditions, with the 700°C initial starting time and 60°C minute rise in heat process continued and at 930°C vacuum was put into use. The oven at 1180°C for 7 minutes was left for self cooling and kept in cooling by itself for 5 hours.

The Vitadur Alpha porcelain was applied with the coating technique after the last leveling process, according to the manufacturer's instructions, and then the glazing material was applied. Following 4 minute preheating, the oven, kept at 600°C with a 107°C increase over 3 minutes immediately after the preheating, was raised to 920°C and the porcelain samples waiting for 1 minute at this temperature were subjected to 5 minute-cooling and were taken from the oven, thus the glazing process was completed.

Measuring Margial Adaptation of Porcelain Teeth Samples and the Microleakage Values

In the cementation process of the 30 maxillary central teeth samples (10 each prepared by the three methods), glass ionomer based cement was mixed according to the manufacturer's directions (Meron Glass ionomer luting cement, Voco, Cuxhaven, Germany). All of the sample teeth were cemented under a 2 kg of load 5 minutes. Excess cements at the borders of the porcelain crowns were cleaned with hand tools after cementation and then the samples were kept for 24 hours in distilled water at room temperature.

The experimental samples prepared were subjected to 500 repeated thermal cycles, keeping each of them 30 seconds at 5±2°C and 55±2°C. The apex of all sample teeth were coated with a thick coating of sticky wax (Cerawax, Spofa Dental, Jicin, Czechoslovakia) and four coatings of die spacer was applied, forming a gap of 1 mm from the marginal borders of the sample teeth. After the die spacer dried, the sample teeth were kept for 24 hours in 5% basic fuchsin dye.

The teeth were removed form the dye and washed under running water for 15 minutes to completely remove the dye. The die spacer and the sticky wax at the end of the root were cleaned completely with a spatula. They were placed into transparent autopolymerizing acrylic resin so that one third of the teeth roots was in the resin (Ortoplast resin, Vertex, Soesterberg, Holland). Later, smooth cross-sections were taken in the insizo-gingival direction in such a way that they would pass trough the mid central direction of the teeth. For this process, from the sample teeth on the acrylic plates assembled on cross-section making machine, manufactured to operate at low speed (Isomet cutter, Buehler, Ilinois, USA) and under water cooling, the cross-section making processes was completed wıth the aid of a diamond spiral disk. The surfaces of the cross-sections were smoothened using sandpaper.

All samples were examined with a surface microscope (Microscope, Nikon MM-400M, Tokyo, Japon). Following x10 enlargement and zooming adjustments, microscope images of all samples were taken in millimeters using a camera (Panasonic Microskope camera, Panasonic Lumix M 4/3 Adapter, Osaka, Japan) placed into the microscope. In the same microscope, of the sample teeth for which cross-sections were made the microleakage ranked in both the palatal and vestibular directions according to the amount of leakage by repeating the process twice (without distinguishing leakage between the tooth-cement and cement- porcelain structures) and gradation ranking was achieved by looking at dye penetration amounts. On the scale formed, the gradation ranking was performed according to the followings:

Microleakage Rankings

There is no leakage at all

There is leakage to $^{1/4}$ of the intermediate surface (Only in the step regions)

There is leakage to $^{1/2}$ of the intermediate surface (At upper region of the step)

There is leakage to $^{3/4}$ of the intermediate surface (Below the incisal region)

There is leakage to entire intermediate surface (Including the incisal region)

For the marginal adaptation rankings, all of the sample teeth for which cross-sections were made were moved into the metal microscope (Scherr Turico St. James/Minn./USA) and the marginal adaptation degrees were measured in both palatal and vestibular regions by measuring twice with x10 enlargement at micron level.

Statistical Assessment on Marginal Adaptation and Microleakage Values

The data obtained in the study was evaluated with SPSS (Version 7.5) program and Kruskal-Wallis (KW) test was carried out.

Results

When microleakage values of the In-Ceram Alumina, In-Ceram Zirconia and Finesse groups are compared the differences between the groups are not statistically significant (p>0.05) (Table 1) (Figure 1,2,3,4).

The least leakage was in the Finesse porcelain system in both regions. In the second place, again in both regions, was In-Ceram Alumina. In-Ceram Zirconia caused the most leakage in both regions.

When the marginal adaptation values of the In-Ceram Alumina, In-Ceram Zirconia and Finesse groups are compared in terms of palatal and vestibular values, the differences are not statisticaily significant (p>0.05). (Table 3 and 4)

The most margin opening in the palate is given by Finesse, followed by In-Ceram Zirconia. The smallest margin opening was given by In-Ceram Alumina. In the vestibule, the largest margin opening was given by In-Ceram Alumina, followed by In-Ceram Zirconia. The smallest margin opening was given by Finesse.

In all of the three groups of In-Ceram Alumina, In-Ceram Zirconia and Finesse groups in palatinal and vestibul regions, marginal openings were determined to be at certain values.

Table 1. Statistical Assessment of Microleakage Values in Groups.

Groups	Palate	Median	Vestibule	Median
	X±Se	Values	X±Se	Values
In-Ceram Alumina n=10	1.40 ±0.22	1.50	1.50 ±0,16	1.50
In-Ceram Zirconia n=10	1,10 ±0.31	1.50	1.70 ±0.33	1.50
Finesse n=10	0.80 ±0.24	1.50	0.90 ±0.17	1.50

KW = 2.76 □ KW = 5.20, p>0.05 p>0.05, p-0.251 p=0.074

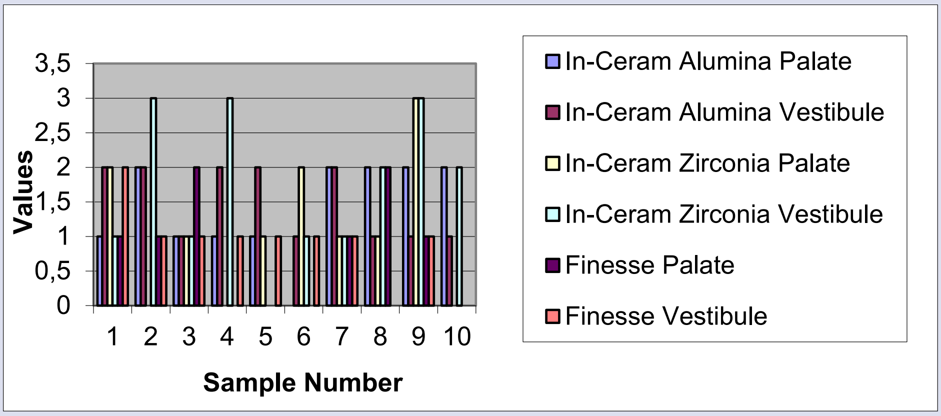

Figure 1. Microleakage values.

Figure 2. Microscopic image taken with x10 enlargement from the sample prepared with the Finesse porcelain system.

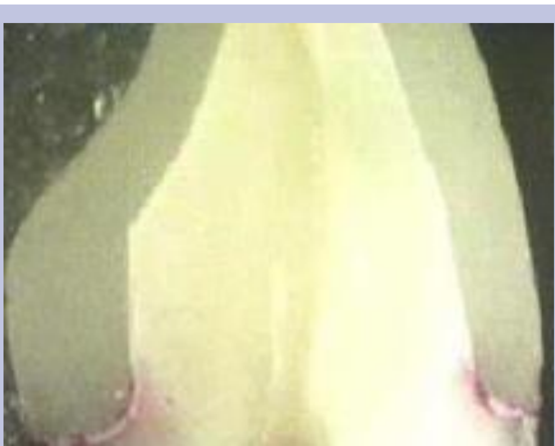

Figure 3. Microscopic image taken with x10 enlargement from the sample prepared with the In-Ceram Alumina porcelain system.

Figure 4. Microscopic image taken with x10 enlargement from the sample prepared with the In-Ceram Zirconia porcelain system.

Table 2. Marginal adaptation values (Measuring twice with xlO enlargement at micron level).

In-Ceram Alumina (Palate)	In-Ceram Alumina (Vestibule)	In-Ceram Zirconia (Palate)	In-Ceram Zirconia (Vestibule)	Finesse (Palate)	Finesse (Vestibule)
200	186	274	82	136	260
36	44	88	134	246	68
144	154	128	236	388	52
94	52	118	118	148	38
72	96	170	30	198	44
72	140	120	68	334	62
194	194	50	56	42	124
122	124	96	140	100	184

Table 3. Statistical evaluation of marginal adaptation in the groups.

Groups	Palate	Palate	Vestibule	Vestibule
	X±Se	Min-Max	X±Se	Min-Max
In-Ceram Alumina n-10	123.80±18.13	36.00-200.00	118.80±17.49	44.00-194.00
In-Ceram Zirconia n=10	130.40±20.84	50.00-274.00	106.80±23.51	30.00-236.00
Finesse n=10	191.20±33.27	42.00-388.00	91.80±26.21	44.00-260.00

Discussion

Microleakage may be defined as the passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it. Many different techniques have been used to demonstrate that, despite what clinicians may like to think, the margins of restorations allow the active movement of ions and molecules. These techniques include the use of bacteria, compressed air, chemical and radioactive tracers, electrochemical investigations, scanning electron microscopy and, perhaps most commonly of all, the use of dye penetration studies.

Investigations of leakage have been carried out both in vivo and in vitro, but the latter is more common. In vitro experiments fail broadly into two categories: those that use a clinically relevant cast which attempts to reproduce the oral situations, and those in which the cast does not represent this and is purely a test of the materials behavior.[8]

Thermal changes are cyclic in nature and their effect can lead to material fatigue and early bond failure. Before establishing marginal adaptation and microleakage, the teeth should be exposed to cold and hot food as in the oral cavity.[9]

Different investigators subjected samples to different numbers of thermal cycles: Beznos 600[10], Ceballos et al. 500[11], and Cardoso 700.[12] Generally, the number of thermal cycle varies between 1 and 2500[13]. According to the Standard ISO/TS 11405: 2003[14] that we used, we executed the process 500 times between the 5±2°C and 55±2°C.

Wendt et al. evaluated the effect of thermocycling on dye penetration during the in vitro microleakage analysis of composites. According to their findings, there was no significant increase of microleakage in restorations when thermocycling was used to simulate temperature extremes, either in dye or water baths, as opposed to restorations that were not thermocycled.[15]

Beznosevaiuated the microleakage at the cervical margins of Class II composite resin restorations restored with different techniques. The results showed that all of the techniques worked well for enamel, with almost no leakage. However, on cementum, all techniques demonstrated moderate to severe leakage.[10]

Sorensen et al. evaluated the marginal fidelity and microleakage of porcelain veneers made with platinum foil and refractory dies techniques. The platinum foil veneers had significantly better vertical marginal fidelity but significantly more overcontouring than had the refractory die veneers. Universal microleakage at the tooth-composite resin interface and negligible microleakage at the porcelain-composite resin interface were observed. No relationship was found between the amount of vertical marginal opening and the amount of microleakage.[16]

Schaerer et al. compared the marginal adaptation of three cast ceramic crown Systems (Cerestore, Dicor, and Ceplatec). Cerestore produced an impressive marginal adaptation without technique sensitivity. Dicor produced rounded marginal openings, while Ceplatec produced suitable marginal adaptation.[17]

Holmes et al. measured the marginal adaptation of castable ceramic versus gold crowns. They found no statistically significant difference in the combined absolute marginal adaptation between ceramic and gold crowns. Randomized block ANOVA demonstrated statistically significant differences among individual gold crown samples, but none among individual ceramic crown samples.[18]

Gardner et al. compared the load necessary to cause porcelain failure on traditionally fabricated metal-ceramic crowns cemented to metal tooth analogs with two different types of margins. They found that the load required to cause porcelain fracture in the crowns with porcelain facial margins was statistically significantly greater than that required to cause porcelain fracture for crowns with metal collars.[19]

Weaver et al. evaluated the variable effects of cementation on the marginal adaptation of Dicor, Cerestore, and porcelain fused to metal crowns. They found that marginal adaptation was not improved with a gingival bevel preparation or an increased seating force. The best marginal adaptation was recorded for Cerestore crowns.[20]

The marginal adaptation values determined are higher than the normal values in the literature.

An ideal restorative possesses perfect marginal adaptation and should not be the cause of microleakage. The results of this study indicate that under simulated conditions of thermocycling, all-ceramic porcelain systems have not improved in terms of marginal adaptation or microleakage properties. However, it is necessary to examine long-term clinical data to understand the characteristics of these all-ceramic porcelain systems. When using all- ceramic porcelain systems for prosthetic restorations in clinical practice, the influence of marginal adaptation and microleakage should be taken into consideration.

Conclusions

With the research conducted, the marginal adaptation and microleakage of different all-ceramic porcelain systems (In-Ceram Alumina and In-Ceram Zirconia porcelain systems made on refractor dies in form of core material, and Finesse porcelain system with the heat pressure technique), that can play a role in failure of the same porcelain systems were compared and the results are indicated below.

When the microleakage scores of the In-Ceram Alumina, In-Cream Zirconia and Finesse groups are compared, the differences between the groups are not significant (p>0.05).

When the marginal adaptation values of the In-Ceram Alumina, In-Ceram Zirconia and Finesse groups are compared in terms of palatal and vestibular values, the differences are not statistically significant (p>0.05).

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Conflicts of Interest Statement

None.

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