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Effect of three veneering techniques on fracture resistance and marginal adaptation of zirconia-based crowns

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Abstract

Introduction: The aim of this study was to evaluate the fracture resistance (FR) of zirconia-based crowns veneered with different methods and to assess marginal gap before and after veneering.

Materials & Methods: Thirty zirconia copings fabricated by Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) were divided into three groups. In the porcelain layering (PL) group, the copings were manually veneered with VM9 feldspathic porcelain. In the indirect composite (IC) group, the Gradia indirect composite was veneered on zirconia copings, and for the CAD-on (CO) group, the CAD/CAM-fabricated Vita Mark II veneer was cemented onto the copings. For each sample, the marginal gap values at four points (buccal, lingual, mesial and distal) were measured using stereomicroscope and computer software (Motic Images plus 2.0 ML) before and after veneering process. All crowns were cemented on their dies with resin cement and then were loaded by a universal testing machine for failure. Data were analyzed using one-way ANOVA and post-hoc Tukey tests at significant level of 0.05.

Results: Mean FR was statistically higher in PL group (3005 N) than IC (2026 N) and CO (1605 N) groups (P=0.000). Before and after veneering, mean marginal gap was 43.42µm and 48.47µm for PL group, 44.69µm and 51.06µm for IC group as well as 53.03µm and 56.08µm for CO group, respectively. Marginal gap had no significant difference in study groups before and after veneering (P=0.56 and 0.18, respectively). The lowest change in marginal gap was observed in CO group.

Conclusion: The PL technique might increase the failure resistance of Zirconia-based crowns compared to IC and CO techniques. The marginal gap rate following veneering in all three techniques was within acceptable clinical limits.

Keywords: Computer-aided design, Dental marginal adaptation, Materials testing, Crowns

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بررسی اثر سه تکنیک ونیرکردن بر تطابق لبه ای و مقاومت شکست روکشهای بر پایه زیرکونیا

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چکیده

مقدمه: هدف از این مطالعه بررسی مقاومت شکست (FR) روکش های بر پایه زیرکونیا که با روش های مختلف ونیر شده اند و تعیین میزان درز لبه ای قبل و بعد از ونیر کردن می باشد.

مواد و روش ها: تعداد ۳۰ کوپینگ زیرکونیا ساخته شده با CAD/CAM (computer-aided design/computer-aided machine) به سه گروه تقسیم شدند. در گروه لایه گذاری با پرسلن (PL)کوپینگ ها با پرسلن فلدسپاتیک VM9 به روش دستی ونیر شدند . در گروه کامپوزیت غیر مستقیم (IC) کامپوزیت Gradia Indirect روی کوپینگ ها ونیر شد و در گروه CAD-on (CO) ونیر از سرامیک Vitamark II ساخته شده با دستگاه CAD/CAM روی کوپینگ ها سمان شد. برای هر نمونه میزان درز لبه ای قبل و بعد از ونیر در چهار نقطه(باکال،لینگوال،مزیال و دیستال) با استفاده از استریومیکروسکوپ و نرم افزار (Motic Images Plus 2.0 ML) محاسبه شد تمام روکش ها روی دای های مربوطه با سمان رزینی سمان شدند و سپس در دستگاه تست یونیورسال تحت نیرو قرار گرفتند تا بشکنند. اطلاعات بدست آمده با استفاده از تست های آنالیز واریانس یک طرفه و آزمون post-hoc Tukey با سطح معناداری ۰/۰۵ آنالیز شدند.

یافته ها: میانگین FR در گروه PL (3005N)به طور معنی داری بالاتر از گروه IC (2026 N) وگروه CO (1605 N) بود.(P=0.000) میانگین درز لبه ای قبل و بعد از ونیر به ترتیب در گروه PL 43.42 µm و48.47µm،در گروه IC 44.69 µm و51.06 µmو در گروه CO 53.03 µm و56.08 µm بود. میزان درز لبه ای قبل و بعد از ونیر کردن در گروه های مطالعه تفاوت معناداری نداشت. (P-value به ترتیب 0.18 و 0.56) کمترین تغییرات در میزان درز لبه ی در گروه CO مشاهده شد .

نتیجه گیری: روش پرسلن گذاری می تواند مقاومت شکست روکش زیرکونیا را نسبت به دو روش IC و CO افزایش دهد. میزان درز لبه ای به دنبال ونیر کردن در هر سه روش در محدوده ی قابل قبول کلینیکی قرار داشت.

واژگان کلیدی: طراحی با کمک کامپیوتر، تطابق لبه ای دندانی، آزمایش مواد، روکش ها

Introduction

All-ceramic restorations have become popular alternatives to metal-ceramic restorations due to their biocompatibility, esthetics and high mechanical properties.[1-3] Zirconia among all dental ceramics is the toughest and strongest and one and has been increasingly used to fabricate the fixed partial dentures.[1] Pre-sintered yttrium-stabilized zirconium polycrystals (Y-TZP) are milled with CAD/CAM systems, providing homogenous zirconia frameworks with no imperfections or porosities.[4] Strength and marginal adaptations are two key factors influencing the survival of an all ceramic restoration in the oral cavity.[5] Zirconia has high fracture strength; however, a typical failure occurred in clinic is delamination or chipping of the veneering ceramic.[1-3,6]There are

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numerous factors that can affect the adhesion between zirconia and veneering layer including the mechanical properties of the framework and veneering material (e.g. coefficient of thermal expansion), wettability of the framework, veneering method, framework design and residual stresses at the interface.[3,7-11] Different techniques have been used to veneer the zirconia frameworks. Traditionally, zirconia frameworks are manually veneered with a layer of mixed ceramic powder. This layer is formed larger than the final dimension to compensate for the shrinkage of the veneering ceramic after sintering.[3] Various parameters including duration and number of the firings and cooling, skill of the dental technician, homogeneity of the ceramic and shrinkage of the ceramic influence the outcome of this veneering technique.[4] Other methods of layering such as the CAD/CAM- fabricated ceramic veneering materials, overpressing technique and indirect composite materials have also been introduced.[3, 4,12-14]

Previous studies suggested that indirect composite material could be bonded to zirconia frameworks via application of a phosphate monomer (MDP,10-Methacryloyloxydecyl Dihydrogen Phosphate) and yielding a durable bond strength.[7,13] Kobayashi et al. [15] have shown that the use of MDP-containing primer leads to high bond strength between zirconia and indirect composite. Komine et al. [16] have reported that the application of an acidic functional monomer containing carboxylic anhydride (4-META), phosphonic acid (6-MHPA), or phosphate monomer (MDP) can enhance the bond strength between zirconia ceramics and indirect composite. The decrease in stress with a composite resin veneer was reported to be 15% greater than that with a porcelain. [17]

A relatively innovative method, known as file splitting technique with the generic term of "CAD-on" has been introduced. In this technique, the respective veneer and framework are designed and fabricated with a CAD/CAM unit as well as attached using an adhesive ceramic or cement. This method provides a fully computerized work process, improving the reliability, quality and cost-effectiveness.[18, 19] Choi et al. found a higher fracture strength in zirconia-based crowns veneered with CAD/CAM glass ceramic than in those veneered with feldspathic porcelain using the layering technique or veneered with glass ceramics using the heat-pressing technique .[18] In a study by Kanat et al. , the zirconia frameworks veneered with CAD-on technique than with porcelain layering and overpressing techniques had higher values in mechanical testing. [4] Yilmaz and Aykent [20] reported higher shear bond strength of veneering ceramic to zirconia in CAD-on group than overpressing and porcelain layering (PL) groups.

Moreover, the veneering technique can affect the marginal adaptation of restorations. It has been observed in previous studies [21-24] that the firing cycle of veneering porcelain can have effect on the marginal fitness of zirconia-based crowns. This may be due to the porcelain contraction during firing, leading to the incomplete sitting of the crown and distortion of the coping. if the crown margins have poor fit, the decrease of the longevity of the prosthetics restoration, plaque accumulation, secondary caries and periodontal diseases may be occurred. [25] As several errors happen during the fabrication of a restoration, is rather impossible to delete the marginal gap. The American Dental Association Specification No. 8 announces that the marginal gap should be between 25-40 µm. In another study, 120 µm has been accepted as the maximum tolerable marginal gap. [26]

The aim of the current study was to evaluate the effect of three veneering techniques on the fracture strength of zirconia-based crowns and to measure the marginal gap before and after veneering. Our first null hypothesis was that zirconia-based crowns with different layering techniques had similar fracture resistance, and the second null hypothesis tested was that veneering method would not affect the marginal gap of zirconia-based crowns.

Materials & Methods

This study was approved by the Ethics Committee of Babol University of Medical Sciences, Babol, Iran (with the code of MUBABOL.REC.1393.28). In this in vitro study, the maxillary first premolar plastic model (Nissin Dental Products, Kyoto, Japan) with radial shoulder finishing line (1 mm) 1.5mm, axial reduction with 8 degrees convergence and 1.8mm occlusal reduction was applied for replication.[27] Thirty polyether impressions were formed using a custom impression tray fabricated with light-cured acrylic tray material (Megatray, Megadenta,Radeberg, Germany) and Impregum impression material (3M,ESPE, St. Paul, USA) to duplicate the prepared tooth into metal-dies. The impressions were filled with Duralay pattern resin (Reliance Dental Mfg. Worth, USA), and then invested.

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The resin was burnt out, and metal-alloy (Vera Bond2V, Aalbadent, USA) was casted into the mold. Next, the metal master dies were finished and scanned (I3Dscan, Imes-icore, Germany) using the labside contrast spray (Renfert-Scanspray, Germany). The Y-TZP cores were designed and milled with CAD/CAM unit (CORiTECH 250i, Imes-icore GmbH, Eiterfeld,Germany) from zirconia blocks (VITA YZ Disk, Vita Zahnfabrik, Bad Säckingen, Germany). A cutback core design was used so that the crown dimension was decreased all about by 1 mm, leading to a core thickness of 0.5 in axial and 0.8 mm in occlusal surfaces. This anatomical reduced core design ensures optimal support and even thickness of the veneering layer. Besides, the CAD/CAM was used to chose Die spacer thickness of 20 μm. After the milling procedure, the VITA YZ cores were sintered in a furnace (iSINT HT-S, Imes-icore GmbH, Eiterfeld, Germany) for 7.5 hours to obtain the final strength and size.

The measurement of vertical marginal gap in each framework was delineated before applying the veneering layer. The frameworks were set on their corresponding metal dies and held with a screw holding device. Marginal gaps at four points (mid-facial, mid-mesial, mid-distal and mid-lingual) were evaluated by a stereomicroscope (Motic SMZ-143 N2GG, Hong Kong) with a magnification of 40X using computer software (Motic Images Plus 2.0 ML). Three measurements were taken at each point, and the mean value was recorded as the initial fit of the zirconia cores (Fig.1-A).

The layering surface of zirconia core was then air-abraded with 50μ aluminum oxide particles (Easy Blast, Bego, USA) at a pressure of 3 bar and a distance of 10 mm with 1 mm nozzle perpendicular to the ceramic surface for 20 s. After that, the ethanol 96% (Parsalkol, Shiraz, Iran) in an ultrasonic bath (Soltec, Milan, Italy) was applied to clean the samples. Afterwards, according to the layering technique, they were randomly divided into three groups (n = 10 per group).

Group PL: veneered with porcelain layering technique

Group IC: veneered with indirect composite resin

Group CO: veneered with feldspar ceramic and CAD-on technique

In PL group, the zirconia cores were veneered with VITA VM9 feldspathic porcelain (VITA Zahnfabrik, Germany) shade A2. All veneering processes were carried out by an experienced dental technician. The porcelain was applied to cope with the bristle brush, and the silicone index (Speedex,Coltène/Whaledent, Altstätten, Switzerland) was used for uniform porcelain placement. From an impression of an enlarged wax-up (DandIran, Tehran,Iran), the index was made to compensate for the sintering shrinkage of the porcelain (20%). The total thickness of the porcelain veneer was 1.25 mm before firing. Three firings were needed for each sample. The porcelain was glazed (Vita Akzent; Vita Zahnfabrik,Germany) with the final firing.

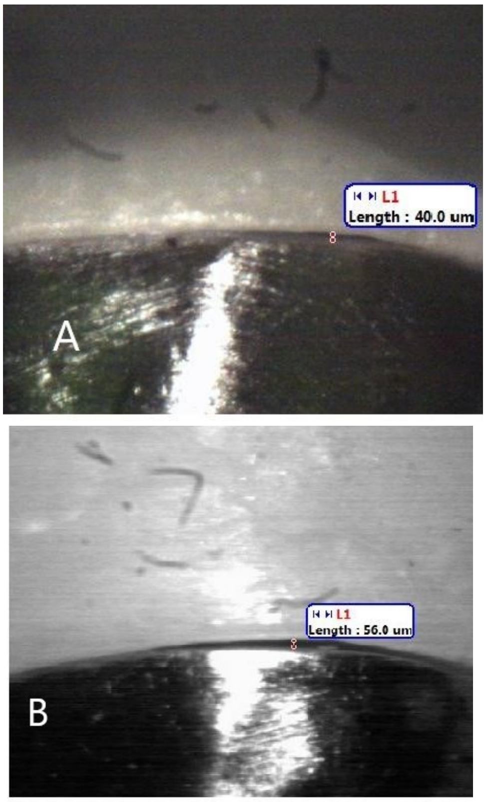

Figure 1. Measuring marginal fitness of crowns on metallic dies under a stereomicroscope (40X). A: before applying the veneering layer, B: after applying the veneering layer

In IC group, the Gradia indirect composite material (GC Corp, Tokyo, Japan) shade A2 was used as a veneering material for the zirconia copings. A layer of Scotchbond Universal Adhesive (3M ESPE, St. Paul, USA) was applied on the zirconia surface, lightly air-dried after 20 seconds and light-cured using a LED light-curing unit (Valo, Ultradent , South Jordan ,USA) with intensity of 1000 mw/cm^2 for 20 seconds. By using a vacuum-formed template (3A MEDES, Ilsan,Korea), the indirect composite resin was put on each core to provide a uniform thickness (1mm) of the veneering layer. Then, the composite veneer was polymerized in GC LABOLIGHT LV-III polymerization machine (GC Corp, Tokyo, Japan) for 3

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minutes. Finally, HighLuster Plus polishing system (Kerr, Brea, USA) was exploited to polish all crowns.

In CO group, the zirconia cores were scanned (I3Dscan, Imes-icore, Germany) and the suprastructures with thickness of 1 mm were designed by the software in the CAD/CAM unit from feldspathic ceramic blocks (Vita Mark II, Vita Zahnfabrik, Germany). The milled ceramic was glazed according to the manufacturer's instructions (Vita Akzent; Vita Zahnfabrik,Germany) . The inner surface of the suprastructure was etched with 9.5% hydrofluoric acid (Pulpdent Corp, Watertown, USA) for 60 seconds, washed for 10 seconds and dried for 5 seconds. A layer of Scotchbond Universal Adhesive (3M ESPE, St. Paul, USA) was used for the etched veneering ceramic surface and the outer zirconia surface. The adhesive was lightly air-dried for 20 seconds and then, light-cured using Valo LED light-curing unit for 20 seconds. The RelyX Ultimate adhesive resin cement (3M ESPE,St. Paul, USA) was applied on the inner surface of the veneering ceramic and inserted on the zirconia core. The cement remnants were eliminated using a disposable micro applicator (Ese International, Taiwan) and after that were photo-polymerized with Valo light-curing unit for 20 seconds on each surface. Subsequently, the borders were polished with Soflex polishing disks (3M ESPE, St. Paul, USA). After veneering process, the fitness of each crown on the corresponding metal die was then measured with the same technique mentioned before. (Fig.1-B). Next, the crowns were luted with Relyx Ultimate adhesive resin cement to the metallic dies under 300 g load for 3 minutes. [4] Before fracture resistance test, all samples were stored in 37$^{\circ C}$ distilled water for 48 hours. The metallic dies were mounted in self-curing acrylic resin (Acropars, Iran) and put in a Universal testing machine (Zwick/Roell,Ulm, Germany) in order to measure the fracture strength of each crown. A 2-mm-thick soft sheet was vacuumed on each sample to supply an even load distribution. [4] A round-tip stainless steel ball of 4mm in diameter was applied at 0.5 mm crosshead speed in a direction parallel to the longitudinal axis of the tooth to load the samples in the center. Until the fracture occurred, loading was used as well as the load at fracture was recorded in Newton (N). Under the same stereomicroscope at X10 magnification, the failure mode of each sample was evaluated and recorded as cohesive fracture of veneering layer and zirconia core, cohesive fracture of the veneering layer, adhesive fracture between the zirconia framework and veneering layer as well as mix fracture when a combination of cohesive and adhesive failures occurred (Fig.2). Statistical analysis was performed with SPSS 20 for Windows (SPSS Inc., Chicago, IL, USA). Data were analyzed using one-way ANOVA, and multiple comparisons were made using Tukey post-hoc test. The p-value<0.05 was statistically considered as significant level in all tests.

Results

The mean and standard deviations of the crowns' failure loads are shown in table 1. Significant differences were seen in fracture resistance of the study groups (p=0.000). The highest and lowest fracture resistance was observed in the porcelain layering (3005 N) and CAD-on (1605 N) groups, respectively. Table 2 illustrates the means and standard deviations for the marginal gap before and after veneering based on the veneering technique.

Table1. Mean, standard deviation, minimum and maximum values of fracture loads (N) of the crowns

Groups	N	Mean (N)	Standard deviation	Minimum	Maximum
Porcelain layering	10	3005.7^{A}	486.5	2289	3811
Indirect composite	10	2026.9^{B}	212.4	1642	2280
CAD-on	10	1605.4^{C}	345.6	1193	2192

Note: Different letters in one column represent significant differences (P-value=0.000)

Table2. Mean±SD marginal gap values before and after veneering, and mean±SD change values in study groups

Group		Porcelain layering	Indirect composite	CAD-on	P-value
Number		10	10	10	
Mean ±SD	Before veneering	43.42± 9.2 ^{a}	44.69±11.09^{a}	53.03±6.7^{a}	0.56
	After veneering	48.47±9.4^{a}	51.06±10.4^{a}	56.08±7.3^{a}	0.18
	Change value	5.04±2.1^{ab}	6.37±2.1^{a}	3.05±0.9^{b}	0.001

Note: Different letters in one row represent significant differences

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There were no significant differences between marginal gaps of the study groups before and after veneering process. ($p=0.056$ and $P= 0.18$ respectively). After veneering, the mean amount of marginal gap in porcelain layering, indirect composite and CAD-on groups increased 5.04µm, 6.37µm and 3.05µm, respectively. The CAD-on group showed the least increase in the amount of marginal gap after layering, which was significantly different from that in the indirect composite group ($P=0.001$).

Figure 2 illustrates different failure modes of the samples in the study groups. The cohesive failures of zirconia frameworks and veneers were only found in PL group (Fig.3).

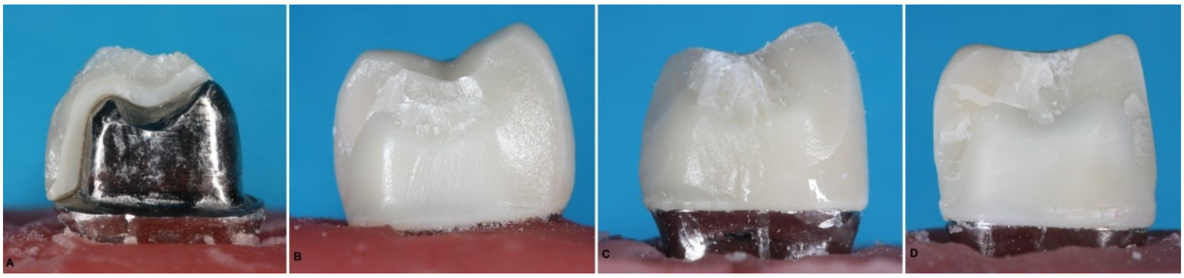

Figure2. Failure modes of samples. A: Cohesive fracture of both veneering layer and zirconia core, B: Adhesive fracture, C: Cohesive fracture of the veneering layer, D: Mix fracture

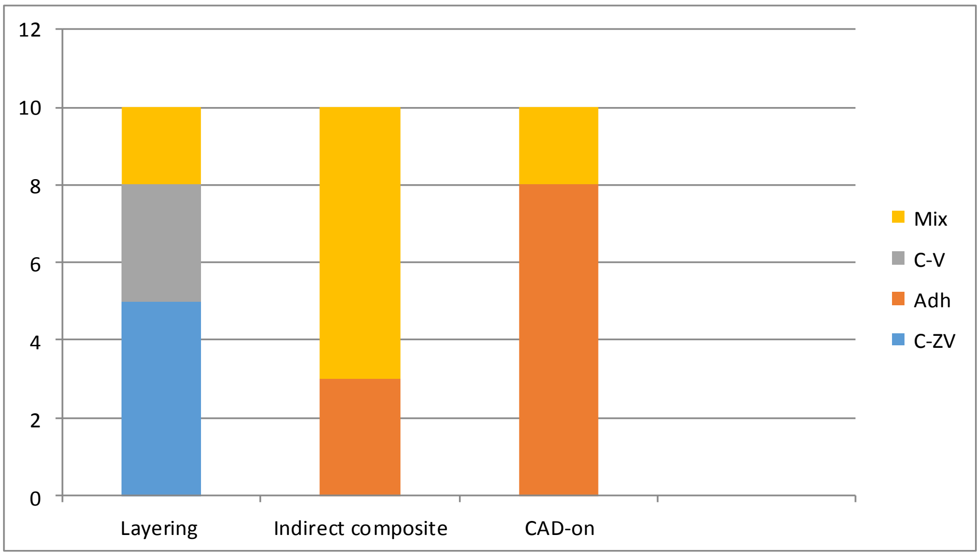

Figure 3. Frequency of failure modes in study groups. Mix: Mix fracture, C-V: cohesive fracture of the veneering layer, Adh: adhesive fracture, C-ZV: cohesive fracture of both veneering layer and zirconia core

Discussion

In the present study, the fracture resistance of crowns with zirconia cores and veneering materials prepared with different techniques (porcelain layering, indirect composite, CAD-on) and the effect on marginal fitness were investigated. The mean fracture strength of the zirconia-based crowns in all study groups exceeded the physiologic maximal posterior masticatory force of 880N. [28] Therefore, it can be conjectured that the restorations' fracture under physiological occlusal forces is improbable. Several studies suggested due to the homogenous thickness of the ceramic and cusp support, a high fracture resistance in zirconia-based restorations with anatomically designed frameworks. [29, 30] Hence, the same design was selected for all samples of the current study. According to the results of the ongoing study, the highest fracture resistance was found in the manually layered feldspathic porcelain group. Thus, our first null hypothesis testing that the veneering method would not influence the fracture resistance of the zirconia crowns was rejected. Satisfactory bond between veneering layer and framework leads to the success of bilayered restorations. The higher fracture strengths in feldspathic-veneered group could be owing to a good bond strength of feldspathic porcelain to zirconia. [31] This finding was also confirmed by the stereomicroscope analyses, demonstrating cohesive fracture of both zirconia framework and veneering ceramic in half of the samples of this group. Like the present study, Kanat-Erturk et al. [3] indicated a higher fracture resistance in the porcelain layering technique compared to overpressing and file-splitting techniques. In their study, the finite element analysis illustrated that the stresses could be transferred to the zirconia framework in a feldespathic-veneered system via a strong interfacial bond, and this bilayered system could act similar to a monolithic structure. [3]

Based on the ongoing results, the fracture strength of indirect composite-layered crowns was lower than that of porcelain-layered crowns. Few studies have investigated indirect composite-layered zirconia-based restorations. [28, 31-33] Contrary to the present study, the studies of Kamio et al. [28] and Taguchi et al. [33] expressed that the fracture strength of indirect composite-layered crowns was comparable to that of feldespathic-layered restorations when a hydrophobic phosphate (MDP) primer was applied. This could be explained by various study designs and composite materials used for veneering zirconia frameworks. In the ongoing study, the Gradia Indirect composite resin was used; on the other hand, Kamio et al. and Taguchi et al. applied Estenia C&B composite. The physical properties of composites may be influenced by differences in the filler content and type of polymerization.[28,33] The inorganic filler content for Estenia C&B was 87.9wt%, but it was 54.1wt% for Gradia.[34] Moreover, secondary curing with heat and light in Estenia C&B would enhance the degree of conversion and its physical properties. [34] The application of this veneering technique might not be beneficial owing to other shortcomings of composite resin including increased plaque accumulation, insufficient wear resistance and surface degradation.[16,35]

In all-ceramic systems, the fatigue properties can be associated number, size and distribution of flaws inherent in the material from various fabrication processes. Therefore, it might be expected that compared to hand layering, a fully sintered CAD/CAD veneering layer with a fewer internal porosities and higher density would lead to better strength properties.[36] Nevertheless, in the present study, the fracture strength of specimens with a CAD/CAM veneer was significantly lower than that of the other groups. This finding is consistent with the result of Kanat-Erturk et al.[3] who declared that the overcemented file-splitting layering method using Vita Mark II compared to porcelain layering technique led to lower fracture strength. The weaker intermediary cement layer at the interface of zirconia and veneering ceramic decreasing the supportive effect of rigid zirconia on the brittle veneering ceramic could be the cause of this lower fracture strength. Choi et al. [18]and Beuer et al. [37] stated a higher fracture strength in zirconia copings veneered with CAD/CAM fabricated glass ceramic (IPS e.max CAD LT), which is inconsistent with the results of the current study. This dissimilarity might be due to the differences in flexural strength of veneering ceramics applied. The used lithium disilicate ceramic for veneering in their studies has a greater flexural strength of 360MPa in comparison to the feldespathic Vita MarkII (154 MPa) ceramic. It has been confirmed that a lesser amount of delamination is occurred through a ceramic with flexural strength of 300 MPa. [38]

Marginal fit of the crown is described as the gap between the intaglio surface of the restoration and prepared tooth. Several methods are applied to measure and access the adaptation of dental restorations including clinical examination, direct view without sectioning the crown, cross-sectional view and impression replica technique. In the current study, the direct view method was utilized as it was a convenient nondestructive technique and commonly applied in previous studies. [5, 39]

Our findings demonstrated that the mean marginal gap of crowns was 48 µm for porcelain layering, 51µm for indirect composite and 56µm for CAD-on techniques, which are closely similar to the results of the previous studies. In the study of Tao et al., [40] the marginal gap of Cercon crowns varied from 40 to 90 µm. Furthermore, Baig et al. [41] evaluated the marginal fit of Cercon zirconia crowns and suggested the overall mean marginal gap of 66.4 µm. The marginal gap in all three veneering techniques was clinically acceptable (120 µm) in previous studies. [42-44]

There were no significant differences in marginal gaps of pre-veneered zirconia framework between groups, indicating that all samples had the same process of machining, designing and sintering. After the veneering processes, marginal gap had increase in all groups; however, the differences between pre-veneered and post-veneered marginal gaps were not significant. Hence, the second null hypothesis was accepted. Regarding the effect of porcelain veneering on the

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marginal gap, several studies displayed different results. Similar to our findings, some studies [23,40,45,46] expressed that the effect of porcelain veneering on marginal fit was not significant. In contrast, others [21,39,47] concluded that porcelain veneering substantially increased the marginal gap. Coping distortion owing to porcelain shrinkage, contamination of the internal surface of framework during porcelain layering and coefficient of thermal expansion (CTE) incompatibility between the core and veneering porcelain can increase the marginal gap; nevertheless, this expansion can be ignored as long as it is within acceptable clinical range range. [21]

Indirect composite veneering materials can substitute with porcelain due to their reparability, abrasion close to tooth structure, approving esthetics and fast laboratory procedure. [48] To our best knowledge, this is the first study to evaluate the effect of indirect composite veneers on marginal fit of zirconia crowns. Although our results represented that the marginal gap of crowns was increased after indirect composite veneering, the difference was not significant. Polymerization shrinkage of composite resin may impose a compressive force on the coping, spreading over the whole circumference of the margin.

The change rate of the marginal gap was lower in the CAD-on group than other groups. This might be due to that in file-splitting technique, the veneering layers were machined from a fully sintered feldspar ceramic blocks and no extra thermal process except for glazing was used, minimizing the gap discrepancy.

The limitations of the ongoing study include a) fracture resistance was assessed under static loading, b) samples were not exposed to artificial aging, and c) marginal fitness was measured on metallic dies. Long-term performance of zirconia-based crowns veneered with different techniques should be further investigated in future in vitro and clinical trial studies.

Conclusion

Within the limitation of this study, it can be concluded that though the porcelain layering technique is time-consuming to perform, it can decrease the fracture of veneered zirconia crowns compared to file splitting and indirect composite veneering technique without detrimental effect on marginal fitness.

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Author’s Contribution

Alhavaz A. developed the study concept and design as well as performed the study supervision, Daneshvar F.A. performed the experimental study, collected data, recorded clinical indices, and prepared the manuscript, Ahmadizenouz G. accomplished manuscript preparation and editing, Bijani A. performed interpretation of data and statistical analysis .

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