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An evaluation of the effect of different veneer materials on fracture resistance of zirconia core

Avaliação dos diferentes efeitos de materiais de revestimento na resistência à fratura do núcleo de zircônia

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ABSTRACT

Objectives: this in vitro study was done to evaluate the effect of packable P60 composite and Tetric N-Ceram composite veneer material on fracture strength of zirconia cores. **Material and Methods:** Twenty four zirconium cores (Vita, Germany) with 0.7 mm thickness were fabricated by CAD/CAM technology and then subjected to air abrasion with 50 μm of Al_2O_3. Cores were randomly divided into three groups according to veneering material (group A: control group sandblasted with 50 μm Al_2O_3 veneered by IPS E-max Ceram porcelain, group C: sandblasted with 50 μm Al_2O_3, etching with hydrofluoric acid and veneered with P60 composite, group E: sandblasted with 50 μm Al_2O_3, etching with hydrofluoric acid and veneered with Tetric N-Ceram composite). All crowns were subjected to fracture strength test in the testing machine, with load application by steel ball indenter and 0.5 mm/min. cross head speed. **Results:** statistical analysis was carried out utilizing one-way ANOVA, LSD. The results of fracture strength value test showed the highest mean value was registered for group (A), and the lowest mean for group (E). One-way ANOVA test represented that, there was a statistically high significant different among all groups. LSD results showed a high significant difference increase in fracture resistance for Group A at p *value* (*p < 0.001 High

RESUMO

Objetivo: o objetivo desse estudo in vitro foi avaliar o efeito dos compósitos P60 compactáveis e material laminado de compósitos Tetric-N Ceram na resistência à fratura de núcleos de zircônia. **Material e métodos:** Vinte e quatro núcleos de zircônia (Vita, Germany) com 0.7 mm de espessura fabricados por tecnologia de CAD/CAM e sinterizados em alta temperatura (1450ºC por 60 min) de acordo com as instruções do fabricante. Núcleos totalmente de zircônias foram submetidos a abração com 50 μm de Al_2O_3. Os núcleos de zircônia foram divididos de forma randomiza em três grupos de acordo com o material de revestimento (grupo A: grupo controle jateado com 50 μm Al_2O_3 folheado com porcelana IPS E-max Ceram, grupo C: jateado com 50 μm Al_2O_3 , coberto com concentração 9,5% de ácido fluorídrico e folheado com resina composta compatível, grupo E: jateado com 50 μm Al_2O_3 coberto com concentração 9,5% de ácido fluorídrico e folheado com porcelana IPS E-max Ceram. Todos os espécimes (coroas) foram submetidos a teste de resistência a fratura com máquina de teste universal, essa máquina utilizou para aplicação de carga bola de aço com 6mm de diâmetro 0,5 mm/min de velocidade da cruzeta. **Resultados:** análise estatística foi realizada utilizando One-way ANOVA, LSD. O resultado da resistência a fratura mostra que o maior valor médio foi registrado no grupo A e a menor média para o grupo E. O resultado do teste One-Way ANOVA representaram que houve uma diferença estatisticamente alta e significante entre todos os grupos. LSD foi executada para mostrar a fonte de significância. Os resultados do LSD mostraram um aumento da diferença significativa alta na resistência à fratura para o grupo A no valor de p (p < 0.001 signicancia alta). **Conclusão:** Dentro

significant). **Conclusions:** Within the limitation of this study, sandblasting zirconia core with 50 μm Al_2O_3 and veneering with conventional ceramic produced restoration with acceptable fracture resistance value.

KEYWORDS

Composite resin; Fracture resistance; Hydrofluoric acid; IPS Emax ceram; Zirconium oxide.

das limitações desse estudo o uso convencional de jateamento com 50 μm Al_2O_3 e estratificação com cerâmica convencional produziu restauração com valor aceitável de resistência a fratura.

PALAVRAS-CHAVE

Ácido fluorídrico; IPS Emax ceram; Oxido de zircônia; Oxido de alumínio; Resina composta; Resistência a fratura.

INTRODUCTION

Ceramics are broadly utilized as materials for restorations because of the ideal characteristics like biocompatibility esthetics and strength. One of the most utilized ceramic in dentistry is Yttria partially stabilized zirconia (Y-TZP) for fabricating frameworkes because of its superior optical and mechanical characteristics [1]. All-ceramic crowns or crowns double layer composed of a highly strength ceramic framework such as alumina or zirconia that veneered with dental porcelain for example feldspathic porcelain. In spite of the consequent restorations have ideal esthetic characteristics, but these restorations subject to failure like fracture of the veneering porcelain [2].

Veneering ceramic can't resisted high tensile stress that finally cause fracture in ceramic. Ceramic restorations likewise may cause wear and abrasive to the opposing teeth [3,4]. Recently, veneering zirconia substructure with high strength indirect composite resin has been proposed as an alternative veneering method to the conventional porcelain veneering system [5].

Composite resins materials are broadly utilized for direct restorations because of their ideal mechanical, optical and physical characteristics, simplicity of manipulating also capacity to be bonded with the tooth structure. [6] To veneer zirconia with composite resins, the bonding between the composite resin and zirconia is a crucial factor. Superior bond strength between the veneering composite resin and zirconia substructure was found in an vitro study by using a zirconia primer [7].

The objective of this study was to investigate the fracture load to failure of the composite veneered zirconia crowns preparing with two different zirconia surface treatments.

MATERIAL AND METHODS

A master metal die was constructed from an ideal pre-prepared plastic right maxillary first molar (Nissin Dental Products, Kyoto Japan), having deep chamfer finishing line (0.8 mm), (2 mm) reduction occlusally. The metal die was fabricated by using "CAD / CAM system" in order to simulate the shape of an ideal prepared plastic die, so that the all ceramic crowns were received [8].

The plastic die was sprayed with dental scan spray, so the reflection of light during scanning process was inhibited. The distance between the plastic die and the nozzle of scan spray bottle was (7 cm) depending to the manufacturer's quidelines. The distance was calculated by placing the die on bech, measuring 7cmm with a ruler from the tip pf spray. The plastic die was inside the dental scanner unit (DOF, full HD, 5M pixel; Korea) w and fixation on scan stage by special clay was done.

A three dimensional image was taken so

that all surfaces and finishing line of plastic die were appeared clearly [9]. The digital model of the die transferred to the CAM software to start the dry milling process of the metal die by using the milling unit which was loaded with cobalt chromium disc (10 mm) (Interdent, Travagliato(BS) Italy).

Base construction of metal die

The base for the metal die was constructed from dental stone type IV to allow proper position of the metal die during scanning. Two grooves were made in the bottom of the metal die for retention of the stone base to the metal die. The dental stone was blended depending to manufacturer guidelines the dental stone was blended (100 g powder/ 20 ml water), vibrated, and poured to 4 mm below the cemento-enamel junction [10] (Figure 1). The stone base was separated from the plastic ring after 40 min according to the manufacturer's instructions. The metal die was surface scanned in the same way as in scanning of plastic die.

Figure 1 - Metal die inside scanner.

Twenty four zirconia core were fabricated. Each core with (0.7mm) thickness was designed to fit on metal die using CAD/CAM technology [11]. Each cores was designed through the software, at that point, the finishing line was drown automatically and the path of insertion was specified and the undercut was checked.

Milling of zirconium core

The suitable Yttria-stabilized zirconia blank was positioned inside the milling apparatus in the blank holder and it was secure with the screw driver, at that point milling procedure was begin. When milling procedure was ended, the zirconia disc was taken away from the holder and the cores framework were disconnected from the disk via disk bur with a laboratory hand piece. The cores were positioned inside sintering furnace and the sintering was performed depending to the manufacturer's recommendations.

Sandblasting the Zirconium Cores

Following sintering, the surface of the zirconium cores were subjected to an air abrasion procedure with (50μm) Al_20_3 particles at pressure (1.5) bar for (10) sec, and sandblasting procedure was at (10) mm fixed distance between the nozzle and the core surface.

The nozzle can be moved in up-down movement without affecting the constant distance between the nozzle and specimen, so all parts of the working surface of core were exposed to sandblast particles during sandblasting procedure, following sandblasting, cleaning with steam jet cleaner was performed for all specimens.

Sample grouping

Twenty four Zirconia were divided to three groups according to the veneering materials used: (The specimens' numbers was based on previuos studies).

Group A: 8 cores were sandblasted and veneered with IPS e.max ceram porcelain (control group).

Group C: 8 cores were sandblasted and used Glaze-on technique by surface treated with Hydrofluoric acid (9.5%) and bonding agent added, then veneered with 3M ESPE Filtek Packable P60 Composite resin.

Group E: 8 cores were sandblasted and used Glaze-on technique and surface treated with Hydrofluoric acid (9.5%) and bonding agent added, then veneered with Tetric Ceram Composite resin.

In group (A), a silicon index was fabricated from putty condensation silicon impression material (Zhermack, Italy) so, an impression was taken to celluloid crown over zirconia core in order to control the thickness of veneering material (2 mm) The index from silicon was made according to manufacturer recommendations by mix up the base with catalyst of the putty condensation silicon rolled into a ball and placed onto a composite crown, then pressed until setting. After complete set, the index was taken away and divided longitudinally from bucco-palatal direction via a surgical blade No.12 [12].

In order to apply veneering ceramic on zircon, the layering technique was used by mixing ceramic powder (50 mg) of IPS E.max Ceram, dentin A3. (Ivoclar Vivadent, Schaan, Liechtenstein, Germany). The powder was mixed with (3 drops) of their special liquid to produce the desired creamy consistency of ceramic (wash dentin) it was applied to the prepared core surface by a brush, with light vibration , excess liquid was blotted with paper tissue, then firing process of ceramic/ dentin was performed in the ceramic furnace according to the manufacturer instructions. In the same manner, The 2nd layer of dentin and enamel porcelain layer were applied in the same manner over the 1st layer and vibrated, it was dried and fired according to the manufacturer instructions. When firing was completed, the dimensions of veneering ceramic were checked by index and Vernier. Sintering furnace cycle for ceramic veneer was illustrated in Table I.

For group (C), the surface of zirconium cores was coated with a very thin layer of glazing porcelain and sintered with glaze firing protocol according to manufacturer's instructions. This procedure called (glaze-on) technique [13].

The glazed surface of zirconia core was etched with hydrofluoric acid (9.5%) for 30 sec, then rinsed with water spray for 60 sec to remove all acid residual and dried with oil-free compressed air.

Prior to composite resin application, Single Bond Universal Adhesive (3M ESPE, USA) was applied on the etched surface and rubbed using disposable brush and lightly air dried for 2 sec, then the bond was subjected to light cure for (20 sec).

A disposable celluloid crown was used to obtain the desired and uniform composite veneering thickness to all composites groups, it was used as a mold for composite resin after adjusted its edge with the die margin and the excess was removed with small scissor. Packable Filtek P60 composie resin was adapted into the celluloid crown. A light cure unit with a power intensity of 600 mw / cm^2 for 20 sec was used for curing the occlusal, buccal, palatal, mesial and distal surface according to manufacturer's recommendations. After the curing procedure was completed, celluloid crown was removed from the restoration.

For group (E): The same procedure of glaze-on technique (etching, bonding, and application of composite resin veneering material) was done as the same manner in group (C) and Tetric N-Ceram composite resin was used as the veneering material. The composition and manufacturers for composite resins used was illustrated in Table II.

For testing fracture resistance, each crown was seated on metal die but without cementation. All crowns were subjected to load to failure test in a universal testing machine (LIoyd LRX-Plus, LIoyd instruments Ltd. Fareham Hants, UK) with a steel ball indenter with a (6 mm) diameter, the cross head speed of (0.5 mm./min) the load was applied occlusally in the (fossa) then, registered in Newton the extreme load causing crown fracture [13] (Figure 2).

The procedures and mechanical test were performed by both authors.

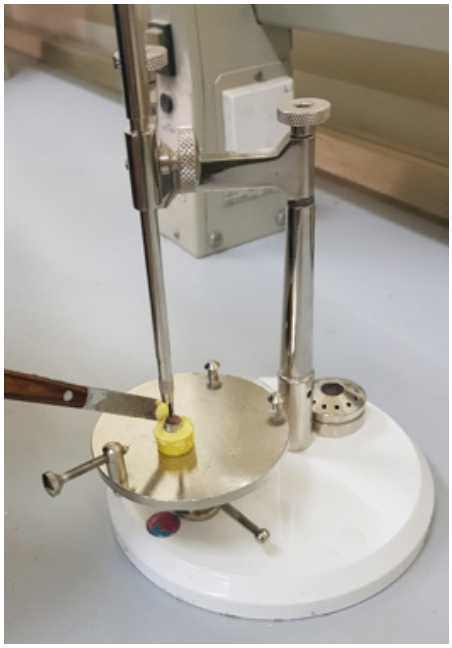

Figure 2 - Making stone base to metal die.

Table I - Sintering Furnace cycle for ceramic veneer

Predry. °C	→ min°	↑min°	↑°C/ min	Temp. approx. °C	→ Min.	↓°C	→ °C	Vac. min.
500	6.00	7.27	55	910	1.00	600*	-	7.27

Table II - Composition and manufacture of composite resin used in this study

Product	Filtec P60	Tetric N-Ceram
Manufacture	3M Dental Products (USA)	Ivoclar Vivadent (Schaan/Liechtenstein)
Composite Type	Packable	Nano-Hybrid Composite
Method of Activation	Visible Light cure	Visible Light Curing
Resin Components	Bis-GMA,UDMA, Bis-EMA.	(19-20 wt. % Dimetha-crylates (Bis-GMA, UDMA)
Filler Type	Zirconia/Silica	(Barium Glass, Ytterbium Trifluride, Mixed Oxide and Copolymers)
Filler Particle Size Range	(0.01-3.5)µm	(40-3000)nm
Filler Loading (Wt. /Vol.)	83%wt. / 61% vol.	80-81% wt. 55-57% vol.
Curing Time	20sec	20 sec.

Failure mode

Failure modes of the fractured specimens were investigated using visual inspection. Two failure modes were categorized as follows: (a) chipping of veneering materials and (b) fracture of core materials and veneering materials together or total fracture.

RESULTS

The descriptive statistics of the values of fracture resistance including: the means, standard deviation, with minimum and maximum values for each veneered groups as shown in table III.

Table III - Descriptive Statistics of fracture resistance of veneered groups (A, C, E) in (Newton)

Group	Minimum	Maximum	Mean	Std. Error	SD
Group A	1721.65	1978.92	1826.4575	38.59839	109.17273
Group C	1331.95	1716.75	1582.4713	41.56172	117.55428
Group E	1092.40	1275.30	1217.0156	24.22378	68.51520

Table III demonstrated, the highest mean of fracture resistance values were in group (A), while the lowest mean of fracture resistance values were for group (E).

One-way analysis of variance (ANOVA) test was done to assess whether there is statically significant difference or not in the mean value among the three groups of veneering zirconium cores, as shown in table IV.

Table IV - One-way ANOVA test for fracture resistance between all veneered zirconium groups

Groups	F	P-value	Sig
All groups (A,C,E)	64.542	.000	HS

*p < 0.001 High significant

According to table IV, One-way ANOVA test demonstrated that there was statistically high significant difference in fracture resistance between the groups at level P. 000.

LSD test was done to located the source of variance among the three groups, as seen in table V.

Table V - LSD test among veneering zirconium groups of fracture resistance

Groups		Mean Difference	Std. Error	P-value	Sig
Group A	Group C	243.98625	52.81988	.000	HS
	Group E	609.44188	52.81988	.000	HS
Group C	Group E	365.45562	52.81988	.000	HS

*p < 0.05 Significant.
**p > 0.05 Non significant.
*** p < 0.001 High significant.

Failure mode

For group A, total fracture was observed with no chipping, whereas for groups C, and E, chipping and delamination for composite resin was observed in 3 specimens in group C, 1 specimen in group E, as shown in Table VI.

Table VI - Mode of failure in %

Group	Chipping	Bulk Fracture	% of chipping	% of bulk fracture
A	0	8	0	100
C	3	5	37.5%	62.5%
E	1	7	12.5%	87.5%

DISCUSSION

In order to control several of the disadvantages related with veneering porcelain with zirconia crown, zirconium substructure veneered with composite was suggested. Such crowns are fabricated with a light cure composites, the advantages of this method incorporate strength, minimal abrasive, biocompatibility of zirconia framework, composite veneer permits simplicity of application also repair intra orally [14-19].

In the present study, the load- to- failure tests or occlusal fracture strength is the one process to examine the structural solidity of that structures which takes into consideration the various component layers and the complications of the crowns anatomy [20]. The cross head speed of 0.5 mm/min. load was applied to the center of the crown by 6mm diameter stainless steel ball [13].

The results of the present study showed a high fracture resistance value in group A and the lowest fracture strength value was in group E this could be explained by that the sandblasting not only brings about morphological changes of material surface, but also increases adhesion efficiency. Also, one prospective factor is the lack of primary stability of zirconia by its transformation from the tetragonal into monoclinic crystallographic phase as an effect of the presence of moisture and elevated temperature [21].

Also, the result of the present study comes in agreement with Su et al. [22] a study showed that sandblasting procedure is a significant surface management that could enhance the bond strength between veneering material and zirconia, and this fine powder particles was more abrasive safely more zirconia was taken off via 50 um of powder particles.

HF was used as a method of treatment have been recommended to improve the bonding strength between zirconia and veneering porcelain by creating micromechanical interlocking [23].

The result of the present study showed a high significant difference for both group C and group E when compared with group A. This could be explained that "Hydrofluoric acid" is utilized when the matrix composed of silicates or silica. Initially, silicon tetrafluoride was formed. Tetraflooride fuse with hydrofluoric acid to form soluble complex ion(hexafluorosilicate) which in turn reacts with hydrogen protons to form tetrafluorosilisic acid, a product that can be selectively removed by water, and the crystalline structure is un covered the outcome surface of the ceramic become rough [24].

The results of this study comes in agreement with Guazzato et al., [14] a study showed that in the adherance of all ceramic restorations, alteration in the surface morphology, just like pores and grooves, are considered important. Both chemical bonding and micro-mechanical interlocking to the surface of ceramic raise the fracture strength of the restoration and the restored tooth, prevent microleakage, improve marginal adaptation and provide high retention.

The result of the current study revealed significant result when comparing all the groups. This could be explained, in packable P60 Filtek, manufactures have increased the filler contact and reduce the average filler particle size by using excessive proportion of irregular (blend of different size glass rods, or particles) or porous filler. In general, packable are loaded in excess of 80% by volum, [25] while the "Tetric Evo Ceram" are generally loaded of 60% by volum, [26] to raising the viscosity, reduce the quantity of resin and creating the particular manipulation property [27]. Packable contain less resin matrix (29% volume) in addition, types of fillers are zirconium and "silica" fiber in which silica scatter light [25].

Moreover, the elevation in the fracture strength of restored teeth might be referred to that composite material utilized in the present study are count less-shrink material, also it had been demonstrated that the utilize of less- shrinkage composites material enhanced the fracture strength of restoration. This results comes in a concurrence with [28] a study deduced that the utilize of less shrink composite material safely reinforced under compression loadings.

As a conclusion , within the limitation of this study, using conventional sandblasting with 50 μm Al_2O_3 and veneering with conventional ceramic produced restoration with acceptable fracture resistance value.

Clinical significance: veneering zirconia core with direct resin composite restoration considered as an alternative method for replacement of chipped or fractured ceramic veneer.

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