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VERTICAL MARGINAL GAP ASSESSMENT OF CAD ON VENEERED PEKK CROWNS VERSUS CAD ON VENEERED ZIRCONIA CROWNS (A RANDOMIZED IN VITRO STUDY)

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ABSTRACT

Aim: This study compared a milled zirconia framework veneered with CAD-On lithium disilicate glass ceramic to a PEKK framework with CAD-On lithium disilicate glass ceramic milled using CAD-CAM milling in order to analyse the vertical marginal gap of the PEKK framework.

Methodology: 14 natural teeth requiring full coverage crown were prepared. The crowns will be divided into two groups:

I: Teeth receiving crowns fabricated from veneered CAD ON zirconia

II: Teeth receiving crowns fabricated from veneered CAD ON pekk.

A uniform 1.5 mm axial reduction (10^0 taper) and 1,5 mm occlusal reduction with a 360^0 deep chamfer finish line (1 mm thickness) was prepared on all teeth. Scanning and designing of the restorations were done and the final design was split in the software into core and veneer layers to be milled separately. Fusion of the veneer to the core was the only manual step done in crown construction; it was done using low fusing glass material (IPS e.max Crystall./ Connect) in the control zirconia group and using adhesive resin cement (multilink) in the PEKK group as recommended by the manufacturer. All the crowns were adhesively cemented on their corresponding preparations using Duo-link adhesive resin cement. All the specimens were subjected to thermo-mechanical fatigue loading for 150,000 cycle simulating one year' clinical service .Vertical marginal gap was assessed using stereomicroscope for the two groups before and after thermomechanical aging for all the specimens.

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Results: ***Pekk group*** recorded statistically significant (P<0.05) higher marginal gap mean value (59.97±2.541 μm) than ***Zirconia group*** (41.79±4.424 μm). regardeless to material type ,totally it was found that after mechanical aging the marginal gap mean value was higher (54.36±13.73 μm) than ***before*** (47.39±10.88 μm) and this was statistically non-significant (P=0.1741 > 0.05) as indicated by two way ANOVA followed by pair-wise Tukey's post-hoc tests

Conclusions: Zirconia showed lower mean marginal gap distance, All specimens evaluated had mean marginal gap distances that were less than 12 μm which was an acceptable clinical value. PEKK can be used as a definitive fixed restorations that have an acceptable marginal gap distance and CAD ON veneering technique can be used as a novel technique for PEKK veneering .

KEYWORDS: vertical marginal gap, PEKK crowns and Zirconia crowns.

INTRODUCTION

Yttria-stabilized (Y-TZP) zirconia ceramicis increasingly used in restorations because of its superior strength and aesthetic qualities. Due to fully-sintered zirconia's remarkable strength, processing it can be challenging because it takes longer and wears out the tool. At the moment, presintered zirconia is primarily used for processing. As a result, after the process, restorations must go through the ultimate sintering. The marginal fit of the zirconia prosthesis after fire is problematic because linear shrinkage by 20–25 percent can happen.

In contrast to PEEK, PEKK exhibits both crystalline and amorphous material characteristics. This makes PEKK especially fascinating.

The frameworks for removable partial dentures as well as fixed restorations including crowns, 3-unit bridges, custom implant abutments, implant-supported superstructures, and telescoping Copings are milled using PEKK in the digital dental CAD/CAM process.

Since these plastics are much easier to mill than metals and do not change their mechanical properties when milled, production runs more quickly, resulting in longer tool lives and less frequent machine maintenance.

However, there haven't been many studies on how poorly PEKK-made restorations fit. The fit of the dental restoration is crucial to the long-term effectiveness of the prostheses since poor marginal fit can lead to plaque formation and subsequent restorative failure.

According to authors and previous studies, marginal gap below 120µm is considered to be clinically acceptable.

METHODOLOGY

Teeth selection:

In this study 14 upper first molars freshly extracted free of caries, attrition, cracks and fractures were used .They were carefully selected with average crown dimensions confirmed by a digital caliper.

Teeth mounting:

A cubic silicone mold (2cmX2cm) was formed to be filled with epoxy resin. Using a parallelometer every tooth was mounted in epoxy.

Teeth preparation:

Before teeth reduction, a putty index was made as a reference. .It was cut buccolingually to create a uniform preparation for all teeth A special milling machine was used for tooth preparation with tapered stone with round end and a specific degree of taper .By a digital calliper diameter of the tapered stone was checked to control the thickness of the finish line during reduction.

A 1.0 mm wide circular deep chamfer finish line was created.According to the manufacturer's instructions, walls were prepared with a taper of 100, uniform axial reduction of 1.5 mm and occlusal anatomical reduction of 1.5mm was made Fig.(1)

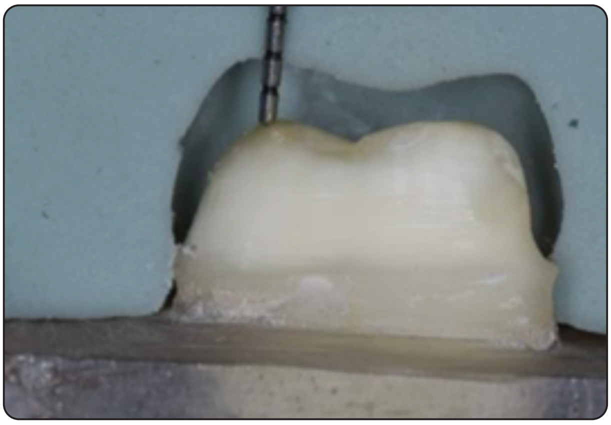

Fig. (1) Uniform occlusal (1.5mm) reduction

Teeth grouping:

According to the type of restorations, fourteen teeth were randomly allocated into two groups as follows:

TABLE (1): Teeth grouping

Group A (control)	Group B (intervention)
n=7	n= 7
Teeth restored by ZirCAD core veneered by e.max CAD	Teeth restored by PEKK core veneered by e.max CAD

Crowns construction:

Zirconia CAD ON Group:

a. Scanning and designing:

The teeth were scanned using an intraoral scanner (Cerec Omnicam), and CAD-on restorations were created using Cerec software version 4.4.

The "Multilayer" design technique was the software tool utilised to produce CAD-on restorations. A fully anatomical crown was first drew out, and then its design was divided into layers for the core and veneer using a specific splitting tool in the software.

For the resultant design, the material thicknesses that are acceptable for each material were changed; the minimum thickness for e.max CAD is 0.7 mm and for ZirCAD is 0.6 mm.

b. Milling:

A 4 axis milling machine inlab MCX was used for milling the The IPS ZirCAD blocks (size C15, shade MO1) and IPS e.max CAD blocks (size 14, HT shade A2) in accordance with the approved design .

By carefully cutting the sprue with a diamond-coated separation disc, both milled IPS e.max zirCAD frameworks and IPS e.max CAD veneers were separated from their holder.

c- Core - veneer fusion/ crystallization:

Using the IPS e.max Crystall./ Connect low fusing special glass, IPS e.max ZirCAD framework and the IPS e.max CAD veneering structure were fused together. A special vibrator device (ivomix)* was used to mix the pre-dosed capsules. To mix the material, the closed IPS e.max CAD Crystall./ Connect capsule was put onto the vibrating plate of the Ivomix for approx. 10 seconds, then the sealing lid was carefully removed from the capsule to make sure that the material was properly mixed and showed a homogenous consistency .With vibration the IPS e.max CAD Crystall. /Connect turns liquid. Without vibration, IPS e.max CAD Crystall./ Connect returns to a firm state, which enables the joined restoration to be checked.

Before crystallization the IPS e.max CAD veneering structure was checked to be in the correct position flushing on the collar of the IPS e.max ZirCAD framework. A special ceramic furnace Programat P510 with a specific pre-drying cycle was used. For use with the IPS e.max CAD-On technique's Fusion/Crystallization firing, a specific fire program featuring an infrared pre-drying function has been created. The sintering temperature of IPS e.max CAD Crystall. /Connect fusion CAD is set such that the crystallisation and fusion processes can be carried out during the same fire cycle (fusion/ crystallization firing).

The Fusion/Crystallization firing was performed with the indicated parameters reaching 8300 firing temperature. From the furnace, the crowns were taken out and let to cool to room temperature. Second, the Stain/Glaze firing was performed. The IPS e.max CAD ./ Glaze paste was applied to the restorations and they were fired in a special glazing cycle.

Before proceeding to cementation, the IPS e.max CAD-On crowns were carefully checked on their corresponding abutment preparations. (Fig2)

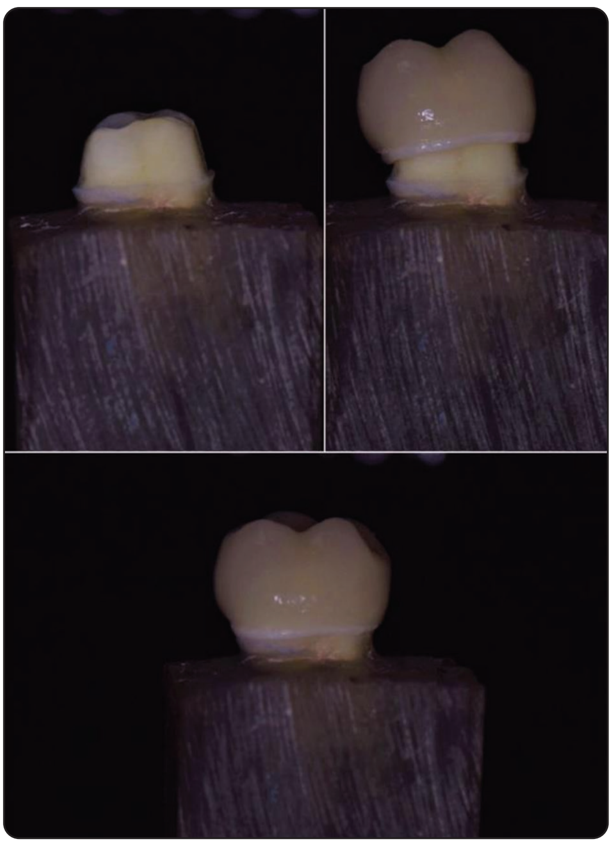

Fig. (2): Try-in of CAD-On crowns

PEKK GROUP

A) Scanning and designing:

The extra-oral 3D scanner T300 was used to scan the teeth preparations. ExoCAD programme was used for design.

The "Multilayer" design technique was the software tool utilised to produce CAD-on restorations. A fully anatomical crown was first designed out, and then its design was divided into layers for the core and veneer using a specific splitting tool in the software.

The manufacturer-recommended values of 0.6 mm for PEKK and 0.7 mm for lithium disilicate were used to standardise the material thickness.

B) Milling:

Using a VHF milling machine and the approved design, a Pekkton® ivory milling blank measuring 98.5/20 mm was produced.

E.max veneer was milled from e.max CAD blocks by MCXL inlab machine .

After detaching the frameworks and the veneers and removing the mill connectors, the PEKK cores were checked on their subsequent prepared teeth. Also the veneers were checked on their subsequent frameworks. They should be flushing with the collar of the framework circumferentially

For crystallization the IPS e.max CAD veneers were supported by an object fix material and fired on their special firing tray according to manufacturers instruction

C) Core - veneer bonding:

Both the outer surfaces of PEKK frameworks and the fitting surfaces of the e.max veneers were abraded with airborne-particles using a special sandblasting device with 110 µm Al_2O_3 powder at 2 bar and then placed in an ultrasonic bath for 5 min.

On the fitting surface of the e.max veneer, ceramic etching gel was applied and left on for 20 seconds. After that, the surfaces were rinsed under running water for 60 seconds, cleaned with an ultrasonic cleaner for another 60 seconds, and dried with oil-free compressed air for 30 seconds. The fitting surface of the e.max veneers was then coated with ceramic primer, which was then given 60 seconds to dry. Afterwards, PEKK outer surface was conditioned using Visio.link by wetting with a thin film using a micro-brush which was immediately polymerized for 90 seconds with a special light curing device (intensity: 220 mW/cm2).

Multilink Automix was injected inside the e.max veneer and placed on PEKK core after removing the excess cement, light cure was applied for 20 second on each side.

Cementation of crowns:

Surface treatment of the fitting surface of Zirconia crowns:

Al2O3 50 m sandblasting was carried out for 10 seconds at a maximum pressure of 1 bar (0.1 MPa).

The restorations' internal surfaces were washed, rinseed, and let to air dry. The bondable surface was evenly wetted with 1-2 applications of Z-PRIME Plus zirconia primer before being air dried for 3-5 seconds.

Surface treatment of the fitting surface of PEKK crowns:

Frameworks were sandblasted with 110 μm and 2-3 bar (0.2-0.3 MPa) pressure.

Visio.link was applied on the sand blasted PEKK surfaces followed by polymerization with a light polymerization device (220 Mw/cm2) for 90 seconds (bre.lux Power Unit) in accordance with the processing instructions.

Treatment of the tooth structure:

Two separate coats of All-Bond Universal were applied, scrubbing the preparation with a micro-brush for 10-15 seconds per coat. Then thoroughly air-drying with an air syringe for at least 10 seconds and the surface had a uniform glossy appearance, excess solvent was evaporated.

Light curing was done for 10 seconds by a light curing device.

Application of adhesive resin cement:

On the fitting surfaces of the crowns, duo-link adhesive resin cement was applied, and the crowns were then seated on the corresponding preparations.

To prevent the crown movement and to maintain the precise crown position, a loading device was used for the placement of a uniform 5 kg (49 N) load along the tooth's longitudinal axis for 10 minutes in accordance with ADA guidelines.

Using an Ivoclar Blue Phase light curing system, each surface of the restoration was cured for up to 40 seconds after excess cement had been removed.

Thermo-mechanical aging:

A 5 kg weight was applied, which is equivalent to a 49 N chewing force. To clinically imitate the chewing condition for a year, the test was run 150 000 times.

Vertical marginal gap measurement:

The vertical marginal gap was measured using a stereomicroscope Leica S8 APO at a magnification of 32X.A built-in camera captures the images.

Each crown is scored out of five on each of its five different aspects (with total 20 points). Both before and after thermomechanical cycling, these measures were made.

RESULTS

Marginal gap

Table (2) and Figure (3) both provide a graphic representation of the descriptive statistics of the marginal gap (m) displaying mean, standard deviation

(SD), lowest, maximum, and confidence intervals (low and high) values as functions of material group and mechanical ageing (3).The mean and standard deviation for PEKK group before aging were (57.43±12.16 μm) with minimum value (44.3 μm) and maximum value (93.37 μm) while after aging (62.51±14.15 μm) with minimum value (39.96 μm) and maximum value (95.45 μm). As demonstrated in table (2) and figure (3) , the difference between the two subgroups was not statistically significant (paired t-test, p=0.3814>0.05)

The mean and standard deviation for Zirconia group before aging were (37.36±5.924 μm) with minimum value (29.3 μm) and maximum value (50 μm) while after aging (46.21±7.169 μm) with minimum value (33.09 μm) and maximum value (70.24 μm). The difference between both subgroups was statistically significant as indicated by paired t-test (p=0.0491< 0.05) as shown in table (2) and figure (3).

Effect of material type on marginal gap result

Regardless to mechanical aging, totally it was found that PEKK group recorded statistically significant (P<0.05) higher marginal gap mean value (59.97±2.541 μm) than Zirconia group (41.79±4.424 μm) as indicated by two way ANOVA followed by pair-wise Tukey's post-hoc tests as shown in table (3) and figure (4)

Effect of mechanical aging on marginal gap result

Regardless to material type, totally it was found that after mechanical aging the marginal gap mean value was higher (54.36±13.73 μm) than before (47.39±10.88 μm) and this was statistically non-significant (P=0.1741 > 0.05) as indicated by two way ANOVA followed by pair-wise Tukey's post-hoc tests as shown in table (4) and figure (5)

Table (2): Descriptive statistics of marginal gap results (Mean values± SDs) as function of material group and mechanical aging

Variables		*Mean± SD*	*Min.*	*Max.*	*95% CI*		*Statistics*	
					Low	*High*	*t-test*	*ANOVA*
PEKK	***Before***	57.43^{A}±12.16	44.3	93.37	49.01	65.86	0.3814 Ns	0.006*
	After	62.51^{A}±14.15	39. 96	95.45	52.71	72.32		
Zirconia	***Before***	37.36^{C}±5.924	29.3	50	33.26	41.47	0.0491*	
	After	46.21^{B}±7.169	33.09	70.24	41.24	51.18		

Different letter in the same column indicating statistically significant difference (p < 0.05)

****; significant (p < 0.05) ns; non-significant (p>0.05)***

TABLE (3) Comparison between total marginal gap results (Mean values± SDs) as function of material type

Variable		Mean± SD	Tukey's rank	Statistics (P value)
Material type	***PEKK***	59.97±2.541	A	0.001 *
	Zirconia	41.79±4.424	B	

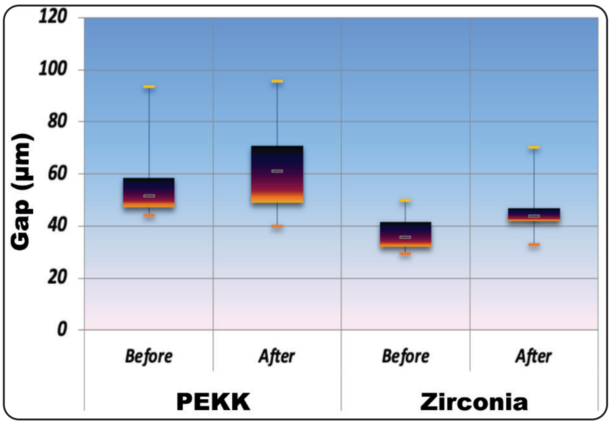

Fig (3): Before and after mechanical ageing, a box plot shows the marginal gap mean values for both material groups

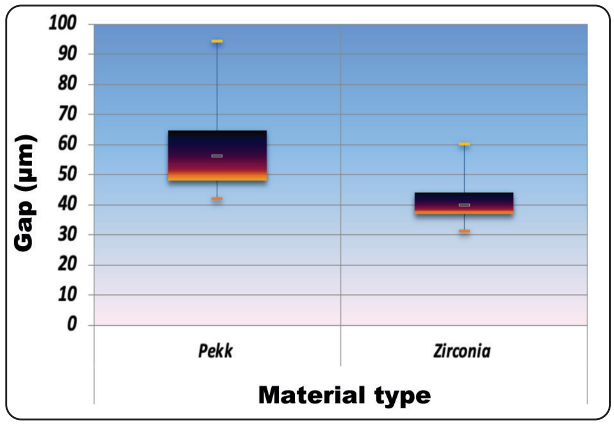

Fig. (4) Box plot of total marginal gap mean values as function of as function of material type

Table (4): Comparison between total marginal gap results (Mean values± SDs) as function of mechanical aging

Variable		Mean± SD	Tukey's rank	Statistics (P value)
Mechanical aging	***Before***	47.39±10.88	A	0.1741 ns
	After	54.36±13.73	A	

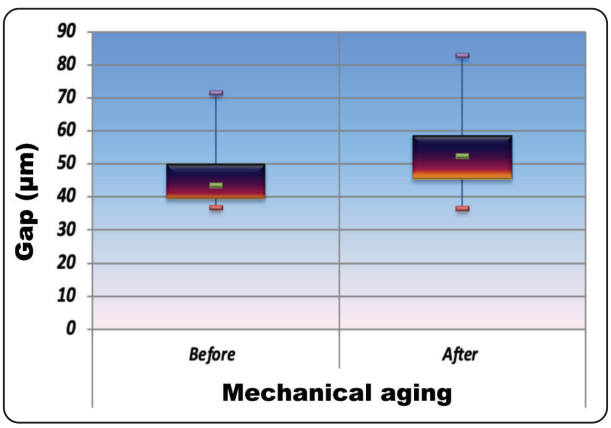

Fig. (5): Box plot shows mean values for the marginal gaps for both the both materials and the aged materials, ordered from higher to lower mean value

DISCUSSION

The use of all-ceramic dental restorations has been risen significantly due to biocompatibility and favourable esthetics. Additionally, possible adverse reactions of metal alloys on tissues have accelerated the development of a metal – free ceramic dental restorations. The development of framework ceramics for fixed prosthodontics represents the transition toward polycrystalline ceramic materials [(1)]

Yttria is added to control the crystal structure transformation during firing at an elevated temperature and enhance the physical properties of zirconia [(2 ,3)]

Although zirconia is now accepted as the gold standard in the field of fixed prosthodontics due to its superior biocompatibility, chemical stability, flexural strength and fracture toughness, its limited capacity to undergo plastic deformation results in fracture at the first sign of increased loading.

PolyEtherKetoneKetones (PEKKs), biocompatible high performance polymers, have recently been introduced as novel dental materials. High performance polymers are seen as an alternative to zirconia because of their acceptable fracture resistance, improved stress distribution, and shock-absorbing capabilities. (4)

Polyetherketoneketone (PEKK), which can be milled or heated-pressed, is chemically stable and very resilient to circumstances of mechanical resistance such stress, fatigue, and bending. In comparison to zirconia, PEKK copings may be slightly more accurate because they don't need to be sintered after milling. (5)

Researches about the marginal fit of restorations fabricated with PEKK are scarce. Therefore, this study was carried out to evaluate vertical marginal gap distance of CAD ON veneered PEKK crowns versus CAD ON veneered zirconia crowns after one year of clinical simulation.

The study was designed to be in-vitro. In vitro research is used for assessing potential new materials or techniques to be further tested in vivo. Clinically, several factors such as tooth preparation, impression technique, and cementation methodology can complicate the testing process and deviate from the ideal situation, making in vivo measurements more complicated than in vitro ones.

Also, in vitro studies offer standardized and optimized conditions in the experimental performance, which may not be achievable in vivo. [6]

Because natural human molars' elastic modulus, bonding properties, thermal conductivity, and strength are more similar to those of clinical situations than those of metal, plastic, and animal teeth, they were used for the assessment of the marginal adaptation in order to standardise the study parameters as much as possible. The teeth were maintained in distilled water to prevent drying out and brittleness (7). A tooth or model should be created in vitro in accordance with the clinical circumstances. Additionally, it's possible that finish lines with a slight curve may be preferable because they more accurately mimic a gingival margin [8]

All teeth preprations were done by the same operator using a standardized technique. A special surveying milling machine with a special chosen stone was used for gross preparation to produce the same amount of reduction with the same degree of taper which was carefully checked afterwards.

The finish line used in this study was deep chamfer (1mm) with 1.5 mm axial reduction with 10° taper and 1.5 mm occlusal reduction, those parameters were selected following the manufacturer's recommendations.

Ten papers looked into the relationship between marginal adaptation and finish line design. Three compared chamfer finish lines with straight shoulder finish lines. Results from chamfer finish lines were superior to those from straight shoulders**.** [9] . **ZAK Al-Zubaidi et al., 2015,** reported that deep chamfer margin could be more preferable than 90° shoulder especially for zirconia full crowns.

Crowns in zirconis group were constructed using cerec software version 4.4 and intraoral scanner was used to scan the teeth.

Crowns in PEKK group were constructed using EXOCAD software and extraoral 3D scanner T300 was used to scan the teeth.

The milling machines used in this study was MCXL (4 axis) machine for milling IPS e.max CAD w IPS e.max ZirCAD and VHF (5 axis) machine for milling PEKK.

The axis of the milling machine has a significant impact on the efficiency of the milling process. At present, milling machines are available with 3, 4, and 5 axes.While 3-axis milling has a simple operation time and short production, There is a restriction to milling the free-form curved fitting surface of the tooth restoration because there isn't a spinning shaft. As a result, a 5-axis milling machine with two rotation axes and a 4-axis milling machine with three axes added to the rotation axis were created. [10]

A 5-axis milling machine provides greater precision than a 4-axis milling machine, according to Bosch et al. (2014). The cost of the prosthesis is decreased by the fact that utilising a 4-axis milling machine is less expensive than using a 5-axis milling machine.The number of the milling axes is not necessarily proportional to the level of accuracy, but it has a large influence on the accuracy of digitization, data processing, and production processes. [11]

As the profits of milling include elimination of porosities resulted from human error and elimination of casting errors by precise milling of frameworks. [12,13]

Milled restorations have been able to produce marginal adaptations as low as 9 to 15 m. [14]

Multi-layering technique (which includes scanning and designing of the crown on the software then splitting the design into core and veneer layers and milling them separately from different materials then fusing them to each other in a separate step) was chosen for the construction of crowns in both groups .

G.R.Basso et al., 2015, concluded that considering the CAD-on technique, the trilayer structures (trilayer specimens of zirconia/fusion ceramic/lithium dissilicate (IPS e.max ZirCAD/ IPS e.max CAD Crystall./Connect/IPS e.max CAD, Ivoclar Vivadent) showed greater fracture toughness than the monolithic zirconia specimens.

Bonding of the IPS e.max CAD to the IPS e.max ZirCAD core was done using a special low fusing glass IPS e.max Crystall / Connect as recommended by manufacturer. A different approach is luting of the IPS e.max veneer over the IPS e.max ZirCAD core with resin cement as in the dental laboratory which is often preferred due to its rapid and easy handling. However, fusion by low fusing glass is recommended by the manufacturer (Technical, i. v., IPS e.max CAD veneering solutions).

Ana Maria Estivalete Marchionatti et al 2019 reported that fused multilayer crowns with special low fusing glass resulted in higher fatigue strength than cemented file-splitting multilayer crowns with resin cement.

Bonding of the IPS e.max CAD to the PEKK core was done using multilink automix resin cement as recommended by manufacturer.

According to the manufacturer's guidelines, the bonding methods for each material utilised were strictly adhered to in order to remove any potential for error during the bonding process.

Duo-link adhesive resin cement was used to cement the crowns to the teeth. Luting procedures were carried out in accordance with clinical guidelines to create an accurate mimic of therapeutically relevant conditions.[15]

It is generally agreed that resin cement bonding to the tooth and crown through both chemical and micromechanical bonding reduces the marginal gap and provides high retention.

Additionally, it functions as a natural buffer layer that can absorb stresses during load application, leading to higher fracture resistance values. [16]

The vertical marginal gap measurement was selected as the most frequently used method to quantify the accuracy of a restoration [17]

Direct view technique with external measurements using stereomicroscope was used in this study to assess the marginal gap. Stereomicroscope was widely used to detect the marginal gap of crowns due to its convenience and briefness. The distance between the crown and tooth structural margin is measured.

For the purpose of standardisation, the same operator performed all measurements. The method used in this study has the advantage of not requiring any sectioning or replications of the cement space prior to measuring the gap, making it less expensive, less time-consuming, and less prone to error accumulation than other techniques that may result from multiple procedures and ultimately affect the accuracy of results. However, it is difficult to repeat this procedure from the same vantage point and to distinguish the actual marginal gap from its projection. [18]

To measure the marginal gap in this study, 5 points from each crown aspect—a total of 20 points for each crown—were chosen.The greater the number of measurements per specimen , the greater the precision of the analysis.At least 20 measurements per crown could be accepted depending on the required level of precision .

For all the specimens, thermomechanical aging were performed to mimic the oral conditions that was proved to have an effect on marginal fit of dental restorations.[19]

In this study m all the specimens were subjected to 150,000 cycles.

According to **Güngör, and Nemli, 2018** 750,000 mechanical cycles represent 5 years of in vivo service considering that 150,000 cycles represent one clinical year.

After thermomechanical aging marginal gap were rechecked using stereomicroscope for all the specimens.

According to the findings of our investigation, the PEKK group recorded a statistically higher marginal gap mean value (59.972.541 m) than the Zirconia group (41.794.424 m), which was statistically significant (P0.05). These outcomes can be linked to the semi-crystalline structure of PEKK, which has a greater potential for marginal chipping during manufacturing than zirconia, which is polycrystalline and has a higher edge strength due to the number of fillers included in the resin matrix.

This may be also attributed to the difference in brittleness index between PEKK and IPS e.max ZirCAD .The machinability of a material can be measured with the calculation of its brittleness index (BI). It is possible that different materials with different BI could produce restorations with varied marginal integrity 20.Further studies are needed to confirm this assumption.

Brittleness index (B) was proposed by **Boccaccini** as a parameter for estimating the machinability and chipping tendency of materials given by the ratio of hardness (H) to fracture toughness (KIc) (B= H/KIc). The lower the brittleness index, the higher the machinability and the lower the tendency of marginal chipping.

Our results were opposed by **Bae et al. (2016) and Park et al. (2017)** who made two recently emerged studies where they compared the marginal and internal fit of CAD/CAM milled PEKK crowns using two and three dimensional analysis methods. They concluded that PEKK crowns showed better marginal and internal fit than the zirconia counterpart.

Therefore, The zirconia group has statistically significantly lower marginal gaps than PEKK, hence the first null hypothesis was rejected.As for the effect of aging on marginal gap values in this study, It was found that regardless the material type after the thermomechanical aging the marginal gap mean value was higher than before thermomechanical aging. However this was statistically non-significant.

Although statistically non-significant, the increase in marginal gap distance may be linked to the thermal cycling. It has been suggested that thermal cycling may stress and weaken the adhesive bond, and causes thermal dimensional changes in the resin cement leading to an increase in the interfacial gap along the margins of the restoration.

It might be also related to fatigue loading, where it was reported that specimens loaded for 105 cycles showed an increase in marginal gaps at tooth-restoration interface. This increase may be induced by the deformation of the dentin interface. [21]

This was in agreement with Khaled el. al's study, which examined the impact of ageing on zirconia crowns using a chewing simulator called ROBOTA and chewing forces of 49 N for 75000 cycles (6 months clinical condition).

They found that there was an increase in the marginal gap after aging .

A study done by **El-Dessouky et. Al** also showed that artificial aging significantly increased the vertical marginal discrepancy of zirconia restorations through thermo-mechanical loading.

On the contrary **Wael et. Al 2009** assumed that the marginal discrepancies had no significant changes after artificial aging, meaning that masticatory simulation had no effect on the marginal accuracy of zirconia fixed partial dentures

As there was no statistical significance, the second null hypothesis was accepted because there was no influence of ageing on the marginal gap between the two groups.

Despite the increase in the marginal gap values after thermomechanical aging, all the obtained data in this study fell within the clinically accepted values.

It was proposed that a restoration would be clinically successful if a marginal gap of less than120 µm could be achieved.[20] That was in accordance with **Bae et al. (2016) and Park et al. (2017)** who concluded that Zirconia and PEKK crowns marginal gap was within clinically acceptable levels.

Different findings between studies could be explained as researchers used different experimental setups and measured the marginal gaps under different conditions. Making the measurement in vivo or in vitro, before or after cementation, before or after veneering, on a chamfer or shoulder finish line, sample size and number of measurements per sample have been found to affect the marginal gap.

As a result of the study being conducted in vitro, where the conditions were different from those in the true intraoral environment, it has a number of drawbacks. The scope of this study was restricted to evaluating the single tooth's marginal gap; a bridge should be included in future studies. Additional clinical researches on the use of PEKK as a definitive fixed prosthesis should be conducted in the future.

Limitations

The following conclusions can be drawn from this study's limitations since zirconia showed a lower mean marginal gap distance than PEKK:

1) The mean marginal gap distance of all analysed specimens was less than 120 µm, which is within the acceptable clinical limits.
2) PEKK can be used as a definitive fixed restorations that have an acceptable marginal gap distance.
3) CAD ON veneering technique can be used as a novel technique for PEKK veneering.

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