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# COLOR ASSESSMENT OF POLY ETHER KETONE KETONE VENEERED WITH DIFFERENT MATERIALS WITH DIFFERENT THICKNESSES AN INVITRO STUDY

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## *ABSTRACT*

**The purpose of this study** was to evaluate the color of PEKK veneers made of various materials and thicknesses.

**Materials and Methods:** The PEKK blanks were used to create 45 discs, totaling 45. They were divided into three groups (n=15) based on the type of veneering materials employed. Discs made of PEKK and veneered with zirconia (Bruxiur) fall into Group A, while those made of lithium disilicate (IPS E.max CAD) and hybrid ceramic (Vita Enamic) make up Group B and Group C, respectively. Then, each group was divded into three subgroups (n=5) based on the thickness of the veneering materials: 0.7, 1.00, and 1.3 mm. Each group's veneering materials were adhered to the treated PEKK surface using Total cem, a dual cure self-adhesive cement. After the specimens were made, they were tested for color change using a spectrophotometer. Then, all of the samples were subjected to thermo cycling, which varies the temperature from 5°C to 55°C at 5,000 cycles. After that, the samples were tested again using the spectrophotometer. The collected data was tallied and analyzed statistically. Thermo cycling results show that E-max has the greatest increase in color change at a thickness of 0.7 mm, where zirconia exhibits the lowest change at a thickness of 1.3mm. In conclusion, the amount to which the restoration materials changed color from their chosen shade was affected by the thickness of the veneering materials. Thermocycling affected the color of PEKK veneer, and zirconia was determined to be the most significant material for the veneer.

**KEYWORDS:** PEKK, zirconia , E-max, hybrid ceramic, veneer

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## INTRODUCTION

Dental professionals have relied on suprastructures made of ceramics fused to metals for a long time to restore patients' smiles and chewing function. Among ceramics' many benefits are their resistance to abrasion and compression, as well as their radiopacity and color stability. [1] Zirconia and lithium disilicate ceramic implant restorations have a higher stress transfer to the implant and peri-implant bone, even if they have a higher survival rate and are biocompatible. Additionally, the opposite tooth's enamel wears down more quickly when exposed to ceramics. [2] Several polymers have been developed for dental usage as alternatives to ceramics, and the interest in metal-free materials is still growing in the field of dentistry.such being the major group (polyaryletherketone) PAEK polymers, which include poyetheretherketone (PEEK) and polyetherketoneketone (PEKK).

PEEK is a viable substitute for ceramics in the dental field. This material's modulus of elasticity is very near to that of bone, making it an excellent shock absorber and reducing the forces communicated to the tissues around the implant. [1] A polyaryletherketone (PAEK) family member, (PEKK) is a semi-crystalline thermoplastic polymer that has excellent chemical and heat resistance. High mechanical loads are not a problem for it. Fixed restorations, custom implant abutments, implant supported superstructures, telescopic copings, and removable partial denture frameworks are milled using PEKK in digital dental CAD/CAM.

However, due to the opaque appearance of these materials, PEKK cannot imitate the natural color of teeth on its own. Therefore, extra veneering is necessary to achieve good esthetics with PEKK.

Currently, there are no studies that compare the optical characteristics of PEKK to other core materials when veneered with other materials, as far as the authors are aware [4-5].

The oral environment has a significant impact on how long a restoration will retain its color. the dental office's repair process using The mechanical and physical qualities of a material can be negatively impacted by its continual exposure to different stimuli, such as changes in humidity and temperature. Laboratory simulations of these oral circumstances can be helpful for evaluating the stability of materials, as they allow for the evaluation of changes in mechanical and optical properties over time. Dental materials can have their durability tested in a number of ways, one of which is thermo cycling. The method relies on subjecting the substance under test to a water bath cycling between hot and cold temperatures, simulating thermal fluctuations similar to those in the mouth.

The study's premise was that PEKK's color reproduction would vary according on the material and thickness.

## MATERIAL AND METHODS

### Materials

This in vitro investigation utilized three distinct dental esthetic materials with specimens of varying thicknesses. zirconia (Bruxiur, prismatik dentalcraft inc USA), E.max (IPS e.max CAD blocks, Ivoclar Vivadent Schaan, Liechtenstein), and hybrid ceramics (Vita Enamic CAD blocks, Vita Zahnfabrik, Bad Sackingen, Germany). Following the application of cement to the samples, color reproduction was evaluated using the Pekkton® ivory milling blank, a product of Centres+Métaux SA of Switzerland.

The procedure involved creating cylindrical samples of each material (PEKK, Bruxiur pucks, IPS e.max CAD, Vita enamic blocks) using specialized computer-aided design (3D Builder, Microsoft, WA, USA) software. The samples had a diameter of 10mm.

The sample size for this study was determined using G*Power software (version 3.1.9.7, University of Düsseldorf, Germany). An effect size of 0.33 was calculated based on data from a previous study[39].

With the significance level (α) set at 0.05 and the statistical power (1–β) at 0.80, the total required sample size was calculated to be 45 participants. This sample size was deemed sufficient to detect statistically significant differences among the groups with an acceptable level of confidence and power.

There were a total of 45 disc examples, with 15 assigned to each of the three categories based on the veneering material: Group A: Zirconia veneered PEKK material. Class B: PEKK with a lithium disclicate veneer. Class C: PEKK with a composite ceramic veneer.

Based on the thickness of the veneer, each group was further separated into three subgroups: Group (n=5) according to Shawn in table (1)

TABLE (1) Study design

| Thickness<br>Veneering materials | 0.7 | 1 | 1.3 | Total |
|---|---|---|---|---|
| Zirconia(Z) | Zs(5) | Zm(5) | Zl(5) | 15 |
| Lithium disclicate(E) | Es(5) | Em(5) | El(5) | 15 |
| Hybrid ceramic(V) | Vs(5) | Vm(5) | Vl(5) | 15 |
| Total | 15 | 15 | 15 | 45 |

**Part I - Preparation of the specimens:**

The experimental study utilized 45 PEKK discs, which were made from PEKK using a CAD/CAM system and machined with certain dimensions (10mm diameter, 0.7mm thickness). To achieve uniform surfaces, grit silicon carbide abrasive paper was used to polish the bonding surfaces while cooling water was applied. A 10-minute ultrasonic water bath was used to clean the surfaces, and then they were allowed to air dry prior to the surface treatment operation.

**First Steps in Making Veneer**

Using a CAD/CAM system, blank A3 was machined to produce veneers made of zirconia, lithium disclicate, and hybrid ceramic. Each material was completed, polished, and subjected to surface treatment in accordance with the manufacturer's specifications. The discs have a diameter of 10 and thicknesses of 0.7, 1.00, and 1.3 mm.

The appropriate digital software was used to build a cylinder with the desired dimension (10mm). Fifteen of each type of disc-shaped specimens (n=45) were produced by slicing the specified cylinders with a diamond saw operating at a low speed in a highly saturated environment. The ceramic specimens were uniformly thinned using a slicing machine equipped with a low-speed diamond blade (Isomet 4000 precision cut, Buehler, USA) (final thickness 0.7,1.00,1.3mm).

In addition, a slicing machine was used to cut the Vita Enamic and Ips e.max CAD cylinders to thicknesses of 0.7, 1.0, and 1.3 mm. Cylinders of BruxZir-shaded zirconia were thicker (2.45 mm) when cut to account for the material shrinkage of 20-30% that occurs during the sintering process with Vita Enamic; however, neither sintering nor firing are required for these specimens. Using a ceramic furnace (Programat P 310, Ivoclar Vivadent, AG, schaan/Liechtenstein) with a temperature range of 840 to 850 °C, the IPS E-max CAD specimen was crystallized. The furnace's pre-programmed settings were limited to the polished ceramic. Following the prescribed sintering temperature chart, BruxZir shaded zirconia specimens were sintered at a temperature of 1580 °C for approximately 8 hours in a sintering furnace (TABEO-1/5 ZIRKON-1000-Germany).

The PEKK discs were sandblasted at a pressure of 2 bar for 10 seconds at a distance of 15 mm and a

90 degree angle to the disk surface, in order to treat their surfaces. The average particle size of the $Al_2O_3$ used was 110 µm. Then, using a light polymerization equipment (bre.lux Power Unit 2W/LED 370-500NM, bredent, Senden, Germany), the treated PEKK surfaces were covered with visio.link and left to cure for 90 seconds.The internal surfaces of the BruxZir shaded zirconia were subsequently treated with z prime plus from BISCO Inc. of Schaumburg, Illinois, USA, after undergoing air particle abrasion with 50 µm Al2O3 at 2 Bar pressure at a distance of 10 mm for 20 seconds.

Samples' surfaces. (Porcelain primer, BISCO Inc.) was applied to IPS.Emax CAD specimens after they had been treated with hydrofluoric acid 9.5% (BISCO Inc. Schaumburg, U.S.A.) for 40 seconds. The Vita Ceramics Etch from Vita Zahnfabrik in Bad Sackingen, Germany, was used to etch (9 Vita Enamic specimens) for 60 seconds. After that, the specimens were rinsed for 60 seconds and allowed to air dry. The hydrofluoric acid gel was sourced from Vita. The specimens' bonding surfaces were subsequently coated with silane and let to dry for 60 seconds.in ten

## Applying Veneer on Pekk Specimens

The bonding surface of the PEKK specimens was coated with Totalcem, a universal dual cure self-adhesive resin cement. Next, the veneering materials' discs were seated and glued to the PEKK substrates using a consistent seating load of 10 N, a standardized static force.[11] A wireless LED light curing equipment was used to cure the specimens for 40 seconds. The light intensity was 1000-1200mW/cm2, and the wavelength was 420-480 nm.

The third part of the process is the spectrophotometric analysis, which involves measuring the color reproduction of each sample using an Agilent Technologies USA spectro-photometer and comparing the results to the (A3) tab of the Vita Classical Shade Guide. Each sample was measured five times with a spectrophotometer and the average reading was recorded. The color change was determined using the following equation:

In this equation, ΔE is equal to the sum of squares of (ΔL*), (Δa*), and (Δb*).ΔL, Δa, and Δb represent the disparity in color change between the specimen values and the values found in the Vita Classical A3 shade tab.

## Thermo-cycling

The bonding groups were given specimens to undergo thermo-cycling in order to study the impact of the process on color change. The groups were PEKK samples veneered with Vita Enamic (n=15), lithium disilicate (n=15), and zirconia (n=15). There were five thousand cycles utilized in this investigation, which is therapeutically comparable to six months. Each water bath had a dwell period of 25 seconds and a lag time of 10 seconds. Fifty degrees Celsius was the lowest point.There was a maximum of 550 degrees.

Analyzing the data statistically involved using IBM SPSS 26 for Windows and the Shapiro-Wilk tests to ensure a normal distribution. The data was presented using mean and standard deviation (SD) values since it followed a parametric distribution. in order to investigate the impact of research factors and the ways in which they interact After utilizing three-way ANOVA, numerous pairwise comparisons were conducted using Tukey's HSD. In all tests, the level of significance was fixed at $P < 0.05$.

## RESULT

Thermo cycling veneering material type and sample thickness interacted significantly ($p<0.001$) before they significantly affected color change. More drastic shifts in hue For example, according to Shawn's table (2) and bar graph, samples with a thickness of 0.7 mm showed less color change than samples with a thickness of 1.00 mm, and samples with a thickness of 1.00 mm showed a bigger color change than samples with a thickness of 1.3 mm.

TABLE (2) Mean, standard deviation, Δ E and p value of materials before thermo cycling

| Thicknes S | Veneering material | Mean | Standard deviation | Δ E | P value |
|---|---|---|---|---|---|
| **0,7mm** | Zirconia(ZS) | 3.54 | 0.14 | 3.54±0.14 | p<0.001 |
| | Lithiumdislic ate(ES) | 5.91 | 0.09 | 5.91±0.09 | p<0.001 |
| | Hybrid ceramic(VS) | 4.84 | 0.12 | 4.84±0.12 | p<0.001 |
| **1.00mm** | Zirconia (ZM) | 3.11 | 0.12 | 3.11±0.12 | p<0.001 |
| | Lithiumdislic ate(EM) | 5.34 | 0.06 | 5.34±0.06 | p<0.001 |
| | Hybrid cerami (VM) | 4.30 | 0.12 | 4.30±0.12 | p<0.001 |
| **1.3mm** | Zirconia(ZL) | 3.08 | 0.13 | 3.08±0.13 | p<0.001 |
| | Lithium disclicat(EL) | 5.00 | 0.15 | 5.00±0.15 | p<0.001 |
| | Hybrid ceramic (VL) | 4.31 | 0.16 | 4.31±0.16 | p<0.001 |

A substantial difference ($p<0.001$) was found between samples that were veneered with different materials.

Samples veneered with E.max showed the greatest amount of color change.

The samples veneered with zirconia had the lowest value, followed by hybrid ceramic and the highest value was with Emax samples . Pairwise comparisons revealed that samples that were veneered with various materials differed considerably from one another (p<.0.001).

**After Thermo cycling**

The results showed that thermo cycling affect color in all groups.

Thermo cycling had a statistically significant increase effect on color of all tested materials (p<.0.001).

When Comparing the color changes (ΔE) across all groups with different thicknesses after thermo cycling, the materials followed this order in terms of color changes : lithium disilicate > hydrid ceramic > zirconia as shawen in table(3) and bar graph in all classes.

TABLE (3) Show mean, standard deviation, ΔE and p value of materials after thermo cycling

| T hickness | Veneering materials | Mean | Standard deviation | ΔE | P value |
|---|---|---|---|---|---|
| 0.7mm | Zirconia (ZM) | 6.30 | 0..24 | 6.30±0.24 | p<0.001 |
| | Lithiumdisl icate(EM) | 7.95 | 0.15 | 7.95±0.15 | p<0.001 |
| | Hybrid ceramic (VM) | 6.53 | 0.12 | 6.53±0.12 | p<0.001 |
| 1.00mm | Zirconia (ZM) | 5.42 | 0.10 | 5.42±0.10 | p<0.001 |
| | Lithiumdisl icate (EM) | 6.91 | 0.12 | 6.91±0.12 | p<0.001 |
| | Hybrid ceramic (VM) | 5.72 | 0.08 | 5.72±0. 08 | p<0.001 |
| 1.3mm | Zirconia (Z L) | 5.10 | 0.21 | 5.10±0.21 | p<0.001 |
| | Lithium disclicate (EL) | 6.73 | 0.05 | 6.73±0.05 | p<0.001 |
| | Hybrid ceramic (VM) | 5.58 | 0.15 | 5.58±0.15 | p<0.001 |

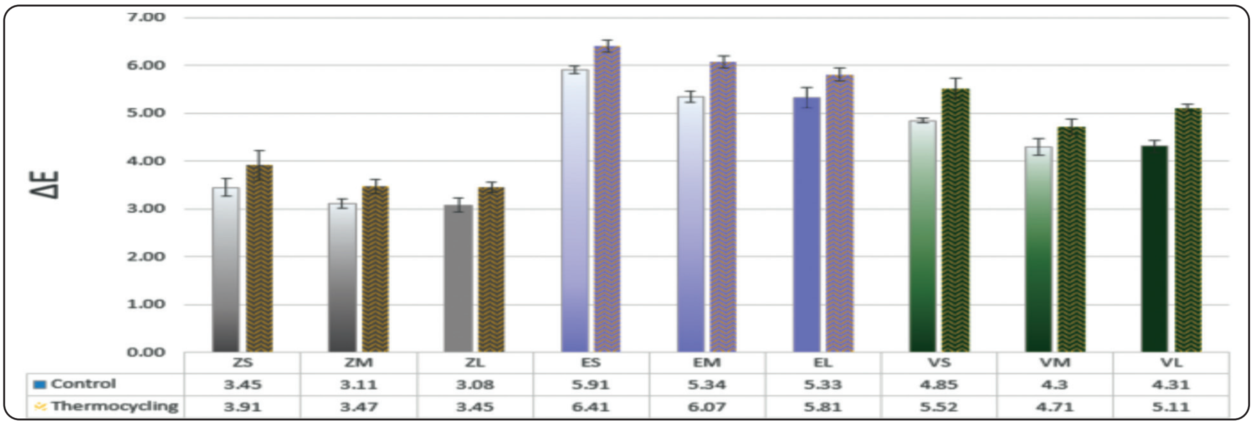


Fig. (1)

## DISCUSSION

In recent years, metal-free restorations have gained popularity as an aesthetic alternative to porcelain fused to metal restorations. This is due to the fact that metal-free restorations more closely resemble the color of natural teeth and do not have coping, which can hinder light transmission.

Asaresult,novelmaterialsAnewdentalframework called bio high-performance polymer (BioHPP) has been developed using polyetheretherketone (PEKK). Despite its many beneficial qualities, such as superior physical properties, low specific weight, and high biocompatibility, BioHPP still needs veneering to get a pleasing aesthetic because of its white-opaque hue. (12)

Cosmetic veneers made of ceramics and composites, which have better physical and mechanical qualities, were first used in dentistry. If the restoration is to enhance the patient's smile, it must match the color, shape, form, and curves of the patient's natural teeth as closely as possible. Several factors, including the type of ceramic material used, the form and contour of the restoration, and its thickness, impact how well the restoration matches the native tooth.

Zirconia, lithium-disclicate, and hybrid ceramic CAD-CAM blocks were utilized in this investigation. as these are the materials that are most commonly used for veneering PE KK.

As a result of its distinctive colloidal and pressed manufacturing technology, Bruxiur zirconia—a 3 mol% yttria partly stabilized zirconia (3Y-PSZ)—offers superior optical qualities and exceptional strength (11) In a study conducted by Islam Abd Alraheam et al. (2019) (12), it was discovered that 3Y-PSZ outperformed 5Y-PSZ in terms of durability when subjected to fatigue testing and thermocycling. This might take a back seat to its metamorphosis capabilities.

A glassy ceramic with a flexural strength of up to 440 MPa is IPS e.max CAD (Ivoclar Vivadent). To improve mechanical stability and reduce crack propagation, glassy matrix is embedded with lithium disilicate crystals. Furthermore, patients had high aesthetic demands, particularly in the anterior aesthetic region, and the material was available in a variety of colors and translucency to meet those demands (13.14)

Vita Enamic is a type of hybrid ceramic with a two-layer network architecture. The main ingredient is feldspar, which is a ceramic matrix that has been reinforced with polymer (UDMA-TEGDMA). The material combines the elasticity of composite with the high strength and resilience to wear of ceramics because to its dual network structure. Therefore, Vita Enamic is very durable and has mechanical qualities that are comparable to real teeth [14] According to Albero et al. (2015), PICN material (Vita Enamic) has a flexural strength and elastic modulus comparable to that of a tooth, while also being less hard than ceramics.

Following the required minimum thickness of core or framework design (16), the PEKK samples were cut to dimensions of 10mm in length, 10mm in breadth, and 0.7mm in thickness.

In order to assess the correlation between veneer thickness and color reproduction, our study utilized three different veneer thicknesses. The dimensions of the E.max and Vita enamic samples were 10 mm in length, 10 mm in width, and (0.7) in thickness (between 1.00 mm and 1.3 mm) in accordance with the veneering material's specified thickness.

Following the manufacturer's specifications, zirconia discs with diameters of 0.88, 1.2, and 1.65 were wafer-cut from the whole height of each cylinder, with an extra 20–25 percent thickness added to account for sintering shrinkage.(17) to increase bond between veneering material and PEKK, a good surface treatment is a must (18). The veneering material's adhesive potential to PEKK is created by sandblasting ($Al_2O_3$ 110 µm at 2 bar), as stated by the manufacturer. Furthermore, Fokasa, G. et al. (2019) proposed that the PEKK material may be effectively bonded to veneering resin by first etching it with $H_2SO_4$ and then blasting it with silica-coated alumina (19). When veneering a PEEK restoration, Stawarczyk et al. (2014) found that an adhesive method (visio.link) was necessary to produce a permanent bond.(2) In order to obtain the best possible bond between the veneering materials and PEKK, they were additionally surface treated.

Joukhadar et al. (2020) found that zirconia specimens exhibited an improvement in resin cement binding strength after airborne particle abrasion and primer application. Also, zirconia primers are more wettable after air abrasions. [8] According to El-Damanhoury et al. (2018), the most reliable method for generating a good bond with lithium disilicate glass ceramics is hydrofluoric acid etching followed by a silane primer. When treating the surface of lithium disilicate, Sudré et al. (2020) found that the acid content and exposure period were major factors. Hence, 10% HF

The most effective results were obtained using lithium disilicate with an acid concentration and an exposure time ranging from 20 to 40 seconds [22].

Ceramics with a hybrid surface treatment. According to Elboraie et al. (2022), bond strength values inside Vita Enamic[10] were positively increased by using HF acid etching and silane coupling agent.

Here, total cem veneer cement was used, a dual light-cured resin cement, for our research. One benefit of using TOTAL CEM cement is that it is easy to work with and doesn't necessitate any prior etching, priming, or bonding. It is easy to remove any excess cement while working. Just three or four seconds of its influence will turn off the light. Superior adhesive properties. Connectivity with enamel strength: 20 MPa. Strength of the dentin bond: 15 MPa. This cement has a fixing strength three times greater than glass-ionomer or hybrid alternatives. Strengthening twice.

For this investigation, TOTALCEM cement was chosen since it was translucent, so it wouldn't impact the final color, as the color of the resin cement affected the color reproduction of the samples [23]. Because standardization methods provide the most reliable results in studies examining variables, the cementation process was carried out under a standardized static load. This lessened the possibility of bias stemming from sample preparation and guaranteed results with high power. To ensure consistency and a uniform coating thickness of cement, specimens in each group were subjected to a constant seating load of 10 N.[24]

The color reproduction of the generated samples was measured using a spectrophotometer and the results were compared to the (A3) tab of the Vita Classic Shade guide.

CIE has It is feasible to assess the degree of detectable color change in each specimen by laboratory measures. The system of color ordering is uniform in three dimensions. The specimen's lightness-darkness is represented by the L* coordinate, where the

A lighter specimen is indicated by a larger L*. On the red-green axis, the a* coordinate expresses the chroma, with positive values indicating more redness and negative values indicating more greenness in the specimen. Along the yellow-blue axis, the b*coordinate measures chroma; a positive value for b* indicates a high degree of yellowness, while a negative value indicates a high degree of blueness in the specimen. Due to the fact that subtle color variations are difficult for the human eye to discern.

The following equation was used to determine the color difference based on the CIELab system for the examination of color change ($\Delta E$), as stated by Kulkarni et al (2020)[25]:

**The equation for $\Delta E$ is half of the sum of $\Delta L^*$, $\Delta a^*$, and $\Delta b^*$ squared.**

It is possible to assess visual color threshold using a mix of subjective and objective measures of color perception. When half of the observers are able to discern a color difference between two objects and half are unable to, we say that there is a 50:50 perceptibility threshold. Half of the people who looked at it found the hue difference to be acceptable. According to Paravina et al. (2009), a color difference is considered acceptable for values below this threshold, and vice versa [26].

Stawarczyk et al. (2012)[27] and Kang et al. (2020[28] state that $\Delta E$, 3.7 is clinically unsatisfactory and could be easily recognized.

Oral restorations endure mechanical, chemical, and thermal challenges on a daily basis. Thus, it is crucial to conduct in-vitro research using artificial aging methods to replicate these conditions and evaluate color stability and durability. One popular method of artificial aging that mimics the effects of time on the mouth is thermo-cycling [29].

With respect to thermo-cycling, the materials underwent 5,000 cycles in this investigation. According to Morresi AL et al. 2014(31), 10,000 cycles is the same as one year in clinical practice. A dwell period of 25 seconds and a lag time of 10 seconds were allotted to each water bath. The minimum temperature was 5 degrees Celsius. A temperature of 55 degrees Celsius was reached. Temperatures between 5 and 55 degrees Celsius were considered to be the most physiologically relevant range for testing dental materials, according to the ISO standard.

Veneering material significantly affected color change, according to the current investigation. The reason why lithium disilicate had higher $\Delta E$ values is because With a lower crystalline content and a refractive index that is near to the matrix, the PEKK core material exhibits less light scattering and higher transparency, resulting from increased light transmission.

The present investigation confirms previous findings that the type of ceramics materials affect the final hue. A ceramic type's masking ability on a titanium abutment was determined to be statistically significant by Amin Bidaki et al 2024[32]. At both the 1.5 mm and 1 mm thicknesses, zirconia masked the titanium substrate more well. This is according to Vohra et al. Analyze the effectiveness of lithium disilicate ceramics in hiding titanium abutments, They demonstrated that titanium abutments may be concealed by zirconia crowns with a thickness of 0.5 mm, as opposed to 1.5 mm lithium disilicate crowns. This was confirmed by our research.

In regards to masking capabilities, the present study concurred with Alayad etall 2020 [34] that the zirconia and enamic groups had the lowest ΔE values, while the IPS E.Max group had the greatest.

In this work, ΔE was found to be lowered and masking ability to rise with increasing ceramic thickness. In a similar vein, research carried out by

The masking ability of CAD/CAM hybrid ceramics with varying thicknesses was studied by Değirmenci and Rasool, [35].Consistent with the present investigation, they found that increasing the ceramic thickness increased masking. Additionally, it is in keeping with the findings of Rasetto et al. [36], who discovered that a substantial reduction in light transmission and color shift ΔE occurs with a rise in ceramic thickness.

It is worth noting that Powers et al. [37] also found that the opacity of composite resin rises with increasing thickness. Light absorption and scattering properties might be to blame for this.

In all materials, thermo cycling resulted in a notable rise in (ΔE).The present study's findings were in agreement with those of Ashy et al. [38], who had previously shown that zirconia material exhibited a smaller color change (ΔE) than lithium disilicate material.

Our hypothesis of this study was totally accepted that material and thickness has an effect on restoration color. However, additional research is necessary to determine the optimal veneering material and thickness for usage with PEKK core material.

## CONCLUSION

Within the limitation of the current study, the following conclusions can be drawn:

1. Veneering material, thickness and thermo cycling had a significant effect on color change.
2. Zirconia showed a clinical accept color change

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