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VENEERING THICKNESS EFFECT ON THE OPTICAL PROPERTIES OF PEEK RESTORATIONS (IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: Polyetheretherketone (PEEK) can be used as a core material for fixed prosthodontics. However, information about the optimum veneer thickness of veneered PEEK restorations is still scarce.
OBJECTIVES: To evaluate the effect of different composite veneer thickness on the optical properties of PEEK restorations.
MATERIALS AND METHODS: Twenty four (n=24) PEEK (BioHPP granules) core disc-shape specimens of 15 mm diameter and 0.8 mm thickness were fabricated and veneered with composite resin (crea-lign, shade A3). The specimens were divided into three groups according to the veneering thickness: core/veneer thickness (mm) of 0.8/1.0, 0.8/1.5, and 0.8/2.0 for groups I, II, and III, respectively. The clinical spectrophotometer (VITA Easyshade) was used for color comparison with the reference color data of the selected shade stored in the device. Statistical analysis was performed with one-way analysis of variance (ANOVA) and student (Unpaired-sample) "t" test.
RESULTS: The veneering thickness significantly influenced the ΔE values ($p < 0.001$). The mean color difference (ΔE) values for groups I, II and III were found to be 8.22(±0.41), 5.13(±0.43) and 3.23(±0.34), respectively.
CONCLUSIONS: Color of PEEK restorations was significantly affected by the veneer thickness.
The veneer thickness of 2.0 mm showed the best color match with perfect masking ability of the underling PEEK core(ΔE<3.3). In contrast, the veneer thickness of 1.0 and 1.5 mm showed a poor color match with poor masking ability of the underling PEEK core (ΔE>3.3).
KEYWORDS: PEEK, veneering thickness, color difference.

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INTRODUCTION

The achievement of natural looking restorations has dependably been one of the major concerns in restorative and prosthetic dentistry. While, at first sight, the esthetic appearance of any restoration is of great subjective significance for the patient and dentist, other significant perspectives like biocompatibility, function, and longevity play a considerable role (1).

Unfortunately, although many improvements have been accomplished during recent years, color or shade stability is as yet an issue. As esthetic failures are standout amongst the most widely recognized explanations behind replacing restorations, one might want to utilize predictable materials (2).

Core veneered restorations are the foundation for prosthetic dentistry, and the combination of a strong core and an esthetic veneer has proven successful for many decades. Though veneering materials aim to rebuild the outer body of the tooth, abutment and core materials are required to strengthen the integrity and stability of the restoration. However, the shade of the last may greatly impact the appearance of the entire restoration and may hamper adequate esthetics (3, 4).

Because the interest for metal-free treatment choices in dentistry is still expanding, several polymers have been introduced for dental restorations alternative to ceramics (5).

A fairly new polymeric material in this field of dental research is polyetheretherketone (PEEK) - a polymer from the main group PAEK (polyaryletherketone). Due to the excellent physical and biological properties, PEEK has gained wide acceptance in medicine and recently in prosthodontics as it has been recommended being a potential material for fixed dental prostheses (6).

PEEK is a biocompatible material and features a natural tooth-colored appearance as compared to metal restorations. However, the white-opaque color and the low translucency of PEEK still limit its use as a monolithic anatomic contour dental restoration material. Thus, additional veneering or indirect composite resin is required to obtain satisfactory esthetics (6, 7).

A number of variables are involved in achieving an esthetic restoration, among which a veneering material with optimal masking ability of the underlying core substructures which is rationally recommended to achieve acceptable esthetic results.

This study was performed to investigate the minimum thickness of the veneering composite to mask the whitish opaque PEEK core. The null hypothesis of this study is that the color of PEEK restorations would be affected by composite veneer thickness.

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MATERIALS AND METHODS

A Total of 24 PEEK discs veneered with composite resin were fabricated and spectrophotometrically evaluated. The procedures were conducted as follows:

Specimen preparation

Twenty-four disc-shape wax patterns were fabricated (15 mm diameter, 0.8 mm thickness). A machine milled custom-made metal mold (Figure 1) was used for standardization of the size of the specimens.

Figure 1: Custom made metal mold.

The wax patterns were invested with the manufacturer's recommended investment (Brevest for 2 press investment material, Bredent, Senden, Germany), and the definitive PEEK core was fabricated by injection-molding with the conventional lost wax technique using a vacuum press device (Vacuum pressing device for 2 press, Bredent, Senden, Germany) designed for this material. The mold was heated from 630°C to 850°C for wax elimination and then cooled to 400°C. The pre-heated muffle was filled with PEEK granules (BioHPP, Bredent, Senden, Germany) and kept in the preheating oven for 20 min at 400°C. At that temperature, the melted PEEK was vacuum pressed into the mold at a pressure of 4.5 bar. The devesting procedure was followed according to manufacturer recommendation and the investment material was removed in a blasting unit (Oxyker TRIO, Manfredi, Italy) using 110 µm Al_2O_3 (Shera Werkstoff Technologie, GmbH, Germany) at a pressure of 2.5 bar. The discs were finished as recommended with fine cross-cut tungsten carbide burs and Ceragum silicone wheel polisher (Bredent, Senden, Germany). The PEEK core discs thickness were verified using an electronic digital caliper (INSIZE, Jiangsu, China) (±0.05 mm) and were ready for veneering with composites. The PEEK core discs were randomly divided into three groups (n=8 per group) according to the applied veneering thickness. The specimens grouping were shown in Table 1.

Table 1: Specimens grouping.

Group number	I	II	III
PEEK core thickness (mm)	0.8	0.8	0.8
Composite veneer thickness (mm)	1.0	1.5	2.0
Total thickness (mm)	1.8	2.3	2.8
Number of specimens	8	8	8

Veneering with composites

The PEEK discs surfaces were conditioned by airborne-particle abrasion with 110 mm alumina powder under 2.5 bar pressure and treatment was done with an adhesive agent (visio.link, Bredent, Senden, Germany). In order to prepare the specimens with different veneering thickness, the veneering resin composite (crea.lign, Bredent, Senden, Germany) dentin shade A3 were filled into the custom-made molds containing the PEEK core. The molds allow for a veneering thickness of 1, 1.5 and 2 mm corresponding to groups I, II and III, respectively. Each layer of the veneering resin was light cured for 180 seconds at a wavelength of 370–500 nm using bre.Lux Power Unit (Bredent, Senden, Germany). The surfaces of the specimens were covered with a glass plate to obtain a smooth, bubble-free surface before the polymerization. The dimensions were then checked using an electronic digital caliper (Figure 2). All the steps were done according to the manufacturer's instructions. Figure 3 showing the veneered PEEK specimens.

Figure 2: Measurement of the specimens after veneering using digital caliper.

Figure 3: PEEK specimens veneered by composite.

Spectrophotometric measurements

The spectrophotometer VITA Easyshade V (Vita Zahnfabrik, Bad Säckingen, Germany) was used to measure the color difference. All of the measurements were consecutively performed after a single calibration process in order to standardize the reproducibility and was repeated 3 times for each sample on a dark background using "Restoration" mode of shade A3. The VITA Easyshade calculates the differences for Chroma (ΔC), Hue (ΔH), Lightness (ΔL) and color differences (ΔE). These differences are calculated by the spectrophotometer according to the CIE standards (8).

Statistical analysis

Data were analysed using SPSS software package version 20. For normally distributed data, a comparison between

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two independent population was done using independent t-test while more than two population were analyzed F-test (ANOVA) to be used. In all the analyses the level of significance was set at $p < 0.05$.

RESULTS

Table 2 shows the color values for the PEEK specimens with different veneering thickness.

Table 2: VITA Easyshade color evaluation for PEEK specimens of different veneering thickness. Mean Δ values (SD) are indicated.

	Mean value (±SD)			
Veneer thickness	ΔE	ΔC	ΔH	ΔL
1.0 mm (Group I)	8.22 (±0.41)	7.89 (±0.44)	-3.55(±0.29)	1.83(±0.34)
1.5 mm (Group II)	5.13 (±0.43)	4.86(±0.45)	-4.08(±0.27)	-0.11(±0.51)
2.0 mm (Group III)	3.23 (±0.34)	2.63(±0.30)	-2.84(±0.20)	-1.50 (±0.40)
F	22.65	19.25	8.02	32.65
P	<0.001*	<0.001*	<0.014*	<0.0001*
P1	<0.003*	<0.002*	<0.041*	<0.001*
P2	<0.001*	<0.001*	0.068 N.S.	<0.0001*
P3	0.107 N.S.	<0.0041*	<0.007*	<0.001*

F = ANOVA test, P = probability, P is significant if < 0.05
P1 comparison between group I and II
P2 comparison between group I and III
P3 comparison between group II and III
* significant difference
NS not significant

The mean and standard deviation (SD) of ΔE value was 8.22±0.41 in group I (1 mm veneering thickness). While, the mean ±SD ΔE value in group II (1.5 mm veneering thickness) was 5.13±0.43, whereas the mean ±SD ΔE value was 3.23±0.34 in group III (2 mm veneering thickness). There was a statistically significant difference between group I when compared with both group II ($p<0.003$) and group III ($p<0.001$). There was a statistically non-significant difference between group II compared with group III ($p=0.107$). The comparison between the three studied groups regarding ΔE is shown in Figure 4.

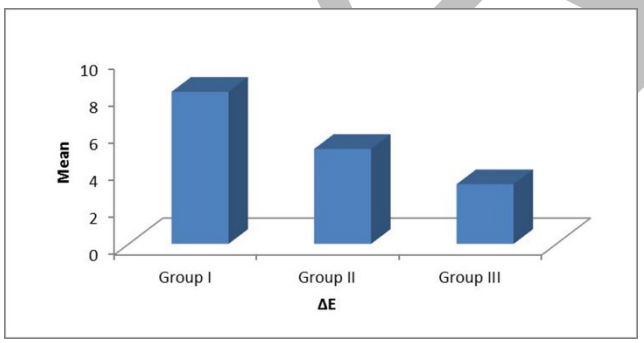

Figure 4: Comparison between the three studied groups regarding mean ΔE.

Statistical analysis revealed that the veneering thickness significantly influenced the ΔE values ($P<0.001$).

DISCUSSION

The increased emphasis on dental esthetics in recent years has developed the need for accurate color replication methods (9). Any error in reconstruction of teeth color restoration can lead to patient dissatisfaction and failure of the treatment. Studies showed that 80% of the patients are dissatisfied due to the color differences between their restoration and adjacent teeth (10). Therefore, precise shade selection and replication are critical in having successful restorations.

PEEK represents a relatively new material and is considered as an alternative in fixed and removable prosthetic dentistry (6). However, PEEK may significantly interfere with the desired esthetic outcomes due to its low translucency and its white-opaque color. Therefore, additional resin composite for veneering are still necessary. However, the color of the core materials may greatly influence the appearance of the whole restoration and may affect adequate esthetics (3).

Therefore, when screening and evaluating potential restorative materials it is important that the materials should have the ability to mimic the natural tooth substance with regard the overall color.

Our study was performed to evaluate the effect of the veneering thickness on the final shade of PEEK restorations.

Flat disc specimens were used in our study in order to facilitate the process of obtaining controlled thicknesses of the veneering material since Barrett et al. found no statistically significant differences in shade-matching accuracy between tab and disc design (11).

For the color measurements of the veneered specimens performed in our study, color differences (ΔE) and the HSB (Hue, Saturation or Chroma and Brightness or Value) parameters have been individually evaluated with the clinical spectrophotometer (Easyshade). The color evaluations performed with the clinical spectrophotometer are not in absolute CIELab* values, but the instrument gives the measurements as a comparison with the color values set in the spectrophotometer.

As spectrophotometers can detect small color differences at a level that is not appreciable by the human eye, an important issue of color science in dentistry is to establish a reference value for the evaluation of study results in terms of ΔE. In other words, if in a study a certain difference in terms of ΔE has been measured, it is important to understand whether this difference can be perceived by the human eye and, if so, whether this difference can be considered clinically relevant. ΔE values of less than 1 unit were regarded as not appreciable by the human eye; ΔE values greater than 1 and less than 3.3 units were considered appreciable by skilled operators, but clinically acceptable; ΔE values greater than 3.3 were considered perceivable by untrained observers (e.g. patients), and for that reason were regarded as not acceptable (12-14).

From the results of this in vitro study, the importance of composite veneer thickness on the color of PEEK restorations was evident as increasing veneer thickness reduced the values of ΔE significantly.

At veneer thickness of 1.0 mm in group I, the mean ΔE was 8.22. This value is considered clinically unacceptable color difference (14-16). Using veneer thickness of 1.5 mm in group II, the mean ΔE was 5.13, this value is considered clinically unacceptable (14,15). However, Douglas et al (16) considered this value as a clinically acceptable. When the veneer thickness was 2.0 mm in group III, ΔE was 3.23 which considered clinically acceptable (14-16).

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These findings were in accordance with Stawarczyk et al (17) who studied the spectrophotometric evaluation of PEEK as a core material and showed that CieLab-System and VITA EasyShade parameters showed a significant impact of core, veneering material, and thickness of the veneering material. Also, the results were coinciding with Zeighami et al (18) who revealed that the veneering thickness affected the color and translucency of PEEK restorations.

It is important to emphasize that the information available to date can be analyzed from an experimental point of view, however, it should be analyzed carefully when applying it to clinical dentistry. The results obtained in this study confirmed the initially formulated hypothesis, i.e., that the color of PEEK restorations would be affected by composite veneer thickness.

CONCLUSION

1. Color of PEEK restorations was significantly affected by the veneer thickness.
2. The veneer thickness of 2.0 mm showed the best color match with perfect masking ability of the underling PEEK core with a ΔE below the acceptable level (ΔE<3.3).
3. The veneer thickness of 1.0 and 1.5 mm showed a poor color match with poor masking ability of the underling PEEK core with ΔE above the acceptable level (ΔE>3.3).

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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