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Patient satisfaction and dentist shade matching of Bio HPP compared to Lithium disilicate crowns in Anterior Aesthetic zone. (Randomized controlled clinical trial)

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Abstract:
Background*: Achieving the patient satisfaction upon restoring single anterior tooth poses the greatest esthetic challenge for the clinician. Selecting the shade of the restoration depends in part on the material used for the understructure, and there is a wide variety of materials available from to choose. New materials are constantly being introduced by manufacturers. Since there are no studies comparing lithium disilicate and Bio HPP materials we have selected this study to evaluate patient satisfaction and dentist shade match of Bio HPP versus lithium disilicate crowns in anterior esthetic zone.*
Materials and Methods*: twenty-four full coverage crowns (12 in each group) were fabricated for teeth requiring full coverage crowns. Patients were divided into two groups according to the type of material used. Group I: IPS e.max crowns and Group II: Bio HPP crowns. The shade of the tooth was recorded visually using VITA 3D-Master shade guide in accordance to the contralateral/adjacent tooth. Shade was also confirmed with Vita Easy shade V spectrophotometer. The fabrication of the crowns was performed using press coping and free hand layering technique. Patient satisfaction was evaluated according to the Rating score while dentist shade matching was evaluated according to modified United States Public Health Services (USPHS) criteria with one year follow up.*
Results: *There was no statistically significant difference among time between the two groups (P-value = 0.0.478) regarding patient satisfaction while there was statistically significant difference among time between the two groups (P-value ≤0.001) regarding dentist shade match.*
Conclusion: *IPS e.max crowns revealed excellent patient and dentist satisfaction while Bio HPP crowns revealed excellent patient satisfaction and clinical accepted shade mismatch by the dentist.*
Key Word: *Patient satisfaction, Shade match, Rating, USPHS, Bio HPP, Lithium disilicate.*

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I. Introduction

The color and appearance of teeth is affected by many factors such as lighting conditions, translucency, opacity, light scattering, surface texture, gloss, etc… [1,2]. Achieving good esthetic results with single anterior crowns is not always easy to obtain and the definitive shade match of porcelain restoration to natural dentition remains a challenge to the dental practitioners and ceramics[3,4]. Also the color of the restoration plays a primary role for patient satisfaction[4]. 89.3 % of patients were dissatisfied of their dental appearance because of their restoration color with its subsequent influence on patient self quality of life and psychological status. Therefore patient satisfaction of the final outcome is important[5,6]. The first step to achieving esthetic clinical success is to correctly identify the tooth color we need to imitate and material that most closely matches and to communicate this information to the laboratory [7]. A variety of different materials were introduced to meet the esthetic requirement such as lithium disilicate ceramic, also many polymers are available for use for fixed restorations such as PEEK (PolyEtherEtherKetone)[8,9,10,11].

II. Material And Methods

This randomized clinical study was carried out on patients of Fixed Prosthodontics Department clinics of Faculty of Dentistry, Cairo University, Cairo, Egypt from October 2018 to November 2019. A total 24 adult subjects (both male and females) of aged ≥ 25 and ≤ 50 years were included in this study.
Study Design: Randomized controlled cclinical trial.
Study Location: This was a teaching hospital based study done in Department of fixed prosthodontics clinic, at Faculty of Dentistry, Cairo University, Cairo, Egypt.

Study Duration: October 2018 to November 2019.
Sample size: 24 patients.
Sample size calculation: The sample size was estimated based on paper by Batson et al., 2014 [2] the clinical performance within each subject group was normally distributed with standard deviation 38.2. If the true difference in the experimental and control means is 45.3 mm, we were needed to study 12 patients in each group to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05. The sample size was calculated by PS program.
Subjects & selection method: The study population was drawn from consecutive Patients who presented to Fixed Prosthodontics Department clinics of Faculty of Dentistry, Cairo University, Cairo, Egypt with anterior tooth indicated for esthetic full coverage restoration from October 2018 to November 2019. Patients were divided into two groups (each group had 12 patients) according to material used as follows:
Group I (N=12 patients): Pressed E-max coping veneered with E-max veneering system.
Group II (N=12 patients): Pressed Bio HPP (Bioactive High Performance Polymer) coping veneered with visio.lign.

Inclusion criteria:
1. Age range of patients was 25-50 years old, able to read and sign the informed consent document.
2. Patient was able to physically and psychologically tolerate conventional restorative procedures and follow up.
3. Patients had no active periodontal or pulpal diseases, had teeth with good restorations.
4. Patient with anterior tooth with problems indicated for full coverage restoration (e.g. mild to moderate discoloration, coronal fracture where partial coverage would lack retention or malformed teeth) Patients were willing to return for follow-up examination and evaluation.
5. Patient with sound contralateral or sound adjacent tooth to the selected tooth required for full coverage.
6. Patient with root canal treated tooth requiring full coverage restoration.

Exclusion criteria:
1. Patient in the growth stage with partially erupted teeth.
2. Patient with poor oral hygiene and motivation.
3. Pregnant women.
4. Patient with psychiatric problems or unrealistic expectations.
5. Patients had no opposing occluding dentition in the area intended for restoration.
6. Patients with parafunctional habits.
7. Color blindness patients are excluded.
8. Patient without contralateral or adjacent tooth to that tooth need restoration.

Procedure methodology

After written informed consent was obtained under the supervision of Research Ethics Committee, Faculty of Oral and Dental Medicine, Cairo University from all patients who participated in this study.

Intra oral examination, photographs (figure(1, 2 and 3)), diagnostic casts and scaling and polishing were performed for each patient before shade selection The color of the tooth was recorded visually using VITA 3D-Master shade guide system accordance to the contra-lateral/ adjacent tooth under different light conditions: natural day light (figure (4)), and color corrected light (figure (5)) to avoid metamerism with the help of five prosthodontists that performed Ishihara's test to determine color deficiency. Their results showed no color blindness. Shade was also confirmed with Vita Easy shade V spectrophotometer (figure (6)). Shade mapping was performed to ensure correct placement of different shade effects and characterizations.

All ceramic anterior tooth preparations were introduced to ideal preparation parameters with deep chamfer finish line was created 1.0 mm diameter using a tapered diamond stone with a round end supra-gingivally along the free gingival margin (figure (7)). The shade of the prepared abutment tooth was recorded visually using the IPS Natural Die Material shade guide under natural day light (figure (8)) and color corrected light (figure (9)) in order to fabricate a die mimicking the oral situation for optimum desired final esthetic results. Final impression was taken using vinylpolysiloxane addition silicon in plastic stock trays. The direct fabricated silicon index was used for provisional restoration construction. Followed by temporary cementation using non-eugenol, acrylic-urethane polymer based temporary cement.

Lithium Disilicate (E-max) ceramic and Bio HPP crowns were fabricated into tooth shape supporting framework by pressing technology then veneered with their veneering system of appropriate shade according to manufacture instruction.

Esthetic try-in of unglazed lithium disilicate crowns was performed using a water-soluble gel[1] under natural day-light (figure (10)) and color corrected light (figure (11)) then confirmed with the Vita Easy-shade V (figure (12)). Stain and glaze firing were performed after verification and adjustments (if needed) according to manufacturer's instructions in the ceramic furnace.

Both lithium disilicate and Bio HPP fitting surfaces were treated according to manufacturer's instruction. In order to remove remnants of provisional cements that may cause a significant decrease in the bond strength of the luting agent, a prophylaxis paste and polishing brush was used for cleaning the tooth surfaces prior to bonding. Then, isolation was granted through the use of rubber dam. Bonding procedures were done using self adhesive translucent luting resin cement according to manufacture instruction (figure (13)). All clinical steps were performed for Group II: Bio HPP crowns in the same manner as previously mentioned for Group I: E-max crowns and according to manufacturer's instructions (figure (14, 15 and 16)).

Five evaluators assessed the outcomes of each group. For patient satisfaction, it was measured using Rating[1] scores ([0, 1 and 2] to denote the set of possible responses [Poor, Good and Excellent]). The Rating scores was customized and translated to Arabic for easier documentation. For Shade matching, it was evaluated in scores by visual mean using Modified USPHS criteria; Alpha: Match tooth, Beta: Acceptable mismatch, Charlie: Unacceptable mismatch and Delta: New restoration is needed. Both scores (patients and dentists) were recorded immediately after crown cementation, 3, 6, 9 & 12 months after review for aesthetics.

Figure 1: Preoperative smiling

Figure 2: Preoperative normal

Figure 3: Intraoral frontal view

Figure 4: Shade selection using 3-D MASTER Shade guide

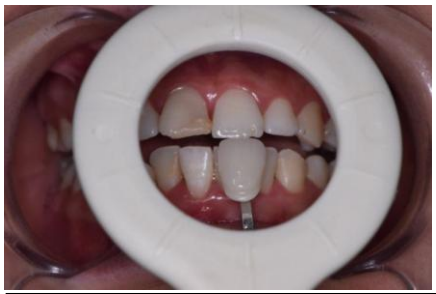

Figure 5: Shade selection using 3-D MASTER Shade guide and color corrected light

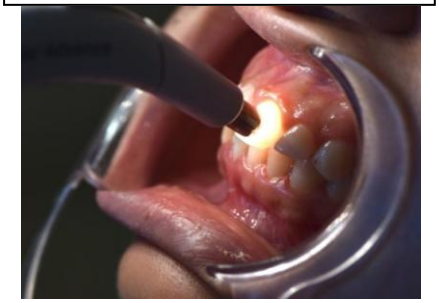

Figure 6: Shade confirmation using Easy shade V spectrophotometer

[1]Clear glycerin

Figure 7: All ceramic tooth surface preparation.

Figure 8: Stump shade selection under natural light.

Figure 9: Stump shade selection under color corrected light.

Figure 10: Esthetic tryin of E-maxc crown

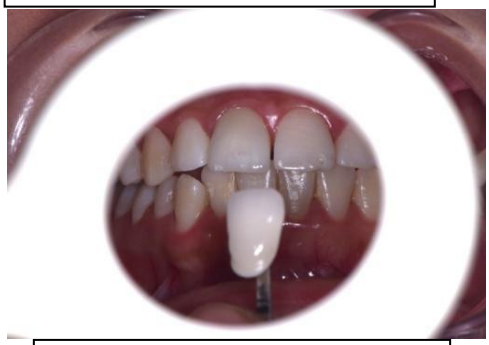

Figure11: Esthetic tryin of ceramic crown using color corrected light.

Figure 12: Esthetic tryin of ceramic crown Easy shade V spectrophotometer

Figure 13: E-max crown after cementation.

Statistical analysis:

Data were presented as frequencies and percentage values. Chi-square test was used to compare between different tested Groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 23 for Windows.

Demographic data:

The present study was conducted on 24 patients, 15 Females and 9 males. The mean and standard deviation values for age were 37.5 with a minimum of 25 and a maximum of 50.

Figure 14: Preoperative intraoral view.

Figure 15: All ceramic tooth surface preparation.

Figure 16: Bio HPP crown after cementation.

III. Result

**Results of patient satisfaction`s assessments:** According to the rating scores, results of comparison between the two groups of The Frequency (N) and Percentage (%) for patient satisfaction`s questionnaire presented in table (1) and figure (17).

At base line (0M): Ten restorations of Bio HPP Group showed (83.3%) Excellent score, while two restorations showed (16.7%) Good score. All restorations of E- max Group showed (100%) Excellent score. There was no statistically significant difference at base time between the two groups (P-value = 0.0.478). Restorations in E- max Group showed the highest prevalence of Excellent score followed Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Good score. All group showed a no prevalence of Unaccepted score.

After 3M follow up: Ten restorations of Bio HPP Group showed (83.3%) Excellent score, while two restorations showed (16.7%) Good score. All restorations of E- max Group showed (100%) Excellent score. There was no statistically significant difference among time between the two groups (P-value = 0.478). Restorations in E- max Group showed the highest prevalence of Excellent score followed by Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Good score. All group showed a no prevalence of Unaccepted score.

After 6M follow up: eleven restorations of Bio HPP Group showed (91.7%) Excellent score, while one restoration showed (8.3 %) Good score. All restorations of E- max Group showed (100%) Excellent score. There was no statistically significant difference among time between the two groups (P-value = 1.00). Restorations in E- max Group showed the highest prevalence of Excellent score followed Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Good score. All group showed a no prevalence of Unaccepted score.

After 9M follow up: eleven restorations of Bio HPP Group showed (91.7%) Excellent score, while one restoration showed (8.3 %) Good score. All restorations of E- max Group showed (100%) Excellent score. There was no statistically significant difference among time between the two groups (P-value = 1.00). Restorations in E- max Group showed the highest prevalence of Excellent score followed by Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Good score. All group showed a no prevalence of Unaccepted score.

After 12M follow up: eleven restorations of Bio HPP Group showed (91.7%) Excellent score, while one restoration showed (8.3 %) Good score. All restorations of E- max Group showed (100%) Excellent score. There was no statistically significant difference among time between the two groups (P-value = 1.00). Restorations in E- max Group showed the highest prevalence of Excellent score followed Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Good score. All group showed a no prevalence of Unaccepted score.

**Results of dentist shade matching`s assessment:** According to the USPHS scores presented in Frequency (N) and Percentage (%) for shade matching`s assessment in table (2) and figure (18).

At base line (0M): one restoration of Bio HPP Group showed (8.3 %) Alfa score, ten restorations showed (83.3

Table (1): Results of statistical analysis of patient satisfaction (Frequency (N) and Percentage (%)).

		Bio-HBB		E.max		p-value
		N	%	N	%	
Baseline	Unaccepted	0	0.0%	0	0.0%	0.478 NS
	Good	2	16.7%	0	0.0%	
	Excellent	10	83.3%	12	100.0%	
	Total	12	100.0%	12	100.0%	
3M	Unaccepted	0	0.0%	0	0.0%	0.478 NS
	Good	2	16.7%	0	0.0%	
	Excellent	10	83.3%	12	100.0%	
	Total	12	100.0%	12	100.0%	
6M	Unaccepted	0	0.0%	0	0.0%	1.00 NS
	Good	1	8.3%	0	0.0%	
	Excellent	11	91.7%	12	100.0%	
	Total	12	100.0%	12	100.0%	
9M	Unaccepted	0	0.0%	0	0.0%	1.00 NS
	Good	1	8.3%	0	0.0%	
	Excellent	11	91.7%	12	100.0%	
	Total	12	100.0%	12	100.0%	
12M	Unaccepted	0	0.0%	0	0.0%	1.00 NS
	Good	1	8.3%	0	0.0%	
	Excellent	11	91.7%	12	100.0%	
	Total	12	100.0%	12	100.0%	

NS=non-significant

Figure (17): Histogram showing the results of statistical analysis of patient satisfaction (in Percentage).

%) Beta score while one restoration showed (8.3 %) Charlie score. All restorations of E- max Group showed (100%) Alfa score. There was statistically significant difference at base time between the two groups (P-value ≤0.001). Restorations in E- max Group showed the highest prevalence of Alfa score followed by Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Beta and Charlie score. All group showed a no prevalence of Delta score.

After 3M follow up: one restoration of Bio HPP Group showed (8.3 %) Alfa score, ten restorations showed (83.3 %) Beta score while one restoration showed (8.3 %) Delta score. All restorations of E- max Group showed (100%) Alfa score. There was statistically significant difference among time between the two groups (P-value ≤0.001). Restorations in E- max Group showed the highest prevalence of Alfa score followed by Bio HPP Group. Restorations in Bio HPP Group were the only restorations that had Beta and Delta score. All group showed a no prevalence of Charlie score.

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HPP Group. Restorations in Bio HPP Group were the only restorations that had Beta and Delta score. All group showed a no prevalence of Charlie score.

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Table (2): Results of statistical analysis of dentist shade matching (Frequency (N) and Percentage (%))

		Bio-HBB		E.max		p-value
		N	%	n	%	
Baseline	Alfa	1	8.3%	12	100.0%	≤0.001*
	Beta	10	83.3%	0	0.0%	
	Charlie	1	8.3%	0	0.0%	
	Delta	0	0.0%	0	0.0%	
3M	Alfa	1	8.3%	12	100.0%	≤0.001*
	Beta	10	83.3%	0	0.0%	
	Charlie	0	0.0%	0	0.0%	
	Delta	1	8.3%	0	0.0%	
6M	Alfa	1	8.3%	12	100.0%	≤0.001*
	Beta	10	83.3%	0	0.0%	
	Charlie	0	0.0%	0	0.0%	
	Delta	1	8.3%	0	0.0%	
9M	Alfa	1	8.3%	12	100.0%	≤0.001*
	Beta	10	83.3%	0	0.0%	
	Charlie	0	0.0%	0	0.0%	
	Delta	1	8.3%	0	0.0%	
12M	Alfa	1	8.3%	12	100.0%	≤0.001*
	Beta	10	83.3%	0	0.0%	
	Charlie	0	0.0%	0	0.0%	
	Delta	1	8.3%	0	0.0%	

**=significant*

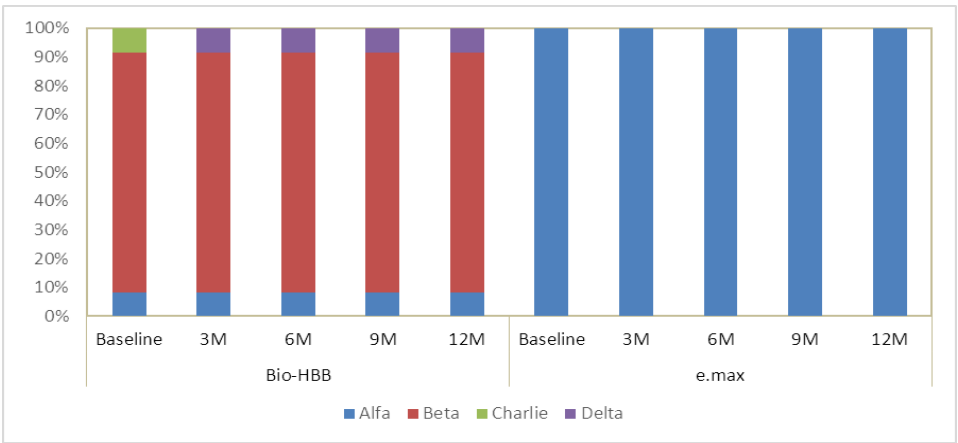

Figure (18): Histogram showing the results of statistical analysis of shade matching (in Percentage %).

IV. Discussion

The increasing esthetic expectations in daily life directly affect the shade selection, techniques, materials and treatment procedures in dentistry, in order to achieve an esthetic successful restoration with perfect shade matching and patient satisfaction.

This randomized clinical comparative study was carried out on patients of Fixed Prosthodontics Department clinics of Faculty of Dentistry, Cairo University, Cairo, Egypt from October 2018 to November

2019. A total 24 adult subjects (both male and females) of aged ≥ 25 and ≤ 50 years were included in this study.

In this study full coverage crowns were fabricated from two different materials: IPS e.max Press coping veneered by IPS e-max Ceram (lithium disilicate crystals embedded in a glassy matrix) ceramic material [12] and Bio HPP (Bioactive High Performance Polymer based on polyether-ether-ketone (PEEK) polymer with 20 % ceramic filler veneered by Visio.lgin composite (50% opalescent ceramic fillers embedded in high strength oligomer matrix)[8].

Pressing technology of the framework with layering technique to fabricate tooth colored restorations were used in this study for both materials. Using layering technique results in the production of restorations with higher value and translucency and also increases patient satisfaction. They also produce restorations with a natural appearance according to Bagis and Turgut, 2013[13].

For the patient satisfaction results; there was no statistically significant difference among time between the two groups. All the patients were satisfied with their restorations (Excellent and Good score consider clinically accepted). Concerning the E-max Group, these results might be reasonable, since it is the combined reflection of meticulous shade matching protocol followed and the Alpha score of ideal shade matching obtained by the prosthodontists evaluators. Concerning the Bio HPP group, these results might be reasonable, since dentists are more sensitive with regard to identifying deviations in shade than are laypeople.

Case 10, female receiving Bio HPP crown: which report Good score among 12 month, stated in her own word "it's more yellowish than my teeth but it still accepting for me" which is similar to shade match Beta score obtained by prosthodontists evaluators. **Case 16,** male receiving Bio HPP crown: which report Good score among 0M & 3M, stated in his own word "it accepting for me but I feel it's slightly lighter than my teeth" which is similar to shade match Beta score obtained by prosthodontists evaluators. While among 6M, 9M &12M, he reported excellent score and stated in his own word "I don't feel any color difference" (which is dissimilar to shade match Beta score obtained by prosthodontists evaluators) and these is might be due to the patient use to the shape and color of his restoration.

Later in 2017, Ballard et al., [14] added that patient reported high satisfaction ratings may have been influenced by the lightness of the restoration shade. While earlier in 2002, Al-Wahadni et al., [1] found that patients tended to rate restorations more favorably when the restoration was received in an academic institution, denoting that patients' pride in the school or positive relationship with the dental student may have elevated his or her opinion of the care received, which came very close to our results.

Contradicting to our results those by Shah et al., 2014[6] who found the overall rating of patient satisfaction was moderate. They explained that patient level of education might affect the results. Patients with secondary, post secondary and tertiary level of education were more satisfied with tooth color compared to patients with primary level of education. In addition, Samorodnitzky-Navek et al., 2007[5] found discrepancy between overall satisfaction with tooth appearance and satisfaction with tooth color. They explained that age might have a significant effect on patient satisfaction as young cohorts of subjects were selected. Studies evaluating the optical properties of Bio HPP material are limited.

For dentist shade matching results; Although following the ideal parameters of shade matching protocol there was statistically significant difference among time between the two groups. This might be due to the available 56 IPS e-max Press ingots which allow wide range shade and translucency selection with possible adequate shade matching results for different clinical cases. While the Bio HPP granules allow only 3 shades; White, Dentine and Pink color. Both White and Dentine shades are highly opaque with impossible adequate shade matching results for different clinical cases. Also dissimilarity in microstructure of both materials IPS e.max (lithium disilicate-based glass-ceramics) and Bio HPP (polyether-ether-ketone based polymer) might affect these differences in shade matching.

PEEK restorations have unaesthetic grey color and appear opaque. It is not suitable for monolithic aesthetic restorations on anterior teeth. Therefore, an additional veneering with composite resin is indispensable to overcome this rather unaesthetical drawback [8,10]. However in our study veneering composite enhances overall appearance and translucency of the restoration but it does not reach that of glass ceramic.

In dental prosthodontics, ceramic materials are considered superior materials to composites from the aesthetical point of view because of their excellent optical properties. Glass-ceramics is a material that mimics dental tissue to a great extent, and has the best optical properties among all prosthetic materials[15]. The advantage of glass-ceramic over other restorative materials is its translucency, which allows the passage of light in the same way as in natural teeth (due to developing procedures of silicate ceramics by controlled glass crystallization) [16].

Concerning IPS e.max crowns, Mazen et al., 2017[17] found the excellent aesthetics outcome with the use of layered lithium disilicate restorations. Fasbinder et al., 2014[18] stated that Alpha scores were noted for lithium disilicate crowns after 2 years of service.

Moreover, Rusu et al.[19], 2018 found that Llithium disilicate veneers showed similar color stability regardless the processing method after 6 month

Contradicting to our results by Chaiyabutr et al., 2011[20] who found color difference of glass-ceramic lithium disilicate reinforced restorations. They explained that this may be due to the optical properties of the material itself that allows the underlying color of the tooth structure to influence the resulting optical color of the crown. In addition, the final color of 1 mm ceramic thickness in the cervical area combined with low translucency ceramic blocks may be affected by intense discoloration of underlying abutment tooth color.

Our results came in agreement of Jirajariyavej et al., 2017 [21] who found that the different ceramic materials affected the final color of the restoration. This color difference between two different ceramic materials may be due to difference in translucency between the hybrid ceramic and the IPS e.max, being more translucent than hybrid ceramic, even both are silica based glass ceramics.

Contradicting to our results, Zoidis et al., 2017[22] found in his case study that the esthetic appearance of the polymer can be equal to that of ceramics since the indirect light polymerized composite materials can be layered like a porcelain material. The combination of PEEK core veneered with indirect composite resin resulted in an uncomplicated clinical evaluation and occlusal adjustment before cementation, without the fear of fracturing the veneering material, when restoring molar with Bio HPP endocrown. Studies evaluating the optical properties of Bio HPP material are limited.

V. Conclusion

Within the limitation of this study the IPS e.max crowns revealed excellent patient satisfaction and dentist shade match while Bio HPP crowns revealed excellent patient satisfaction and clinically accepted shade mismatch by the dentist.

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