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Clinical assessment of color stability and patient satisfaction for polished versus glazed lithium disilicate glass ceramic restorations: Randomized controlled clinical trial

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***Abstract*---**Aim: To evaluate clinically the color stability and patient satisfaction of polished versus glazed lithium disilicate glass ceramic restorations. Methodology: Twenty full coverage crowns were fabricated from IPS e. max press in the posterior area. The patients were randomly divided into two equal groups according to the applied crown surface treatment. Group 1 (control group) 10 glazed crowns and Group 2 (intervention group) 10 polished crowns. ΔE was measured using Vita easyshade and patient satisfaction was evaluated through Visual Analogue Scale (VAS), immediately after cementation and every two months for one year. Data were analyzed using two-way ANOVA and t-test. P ≤ 0.05 was considered statistically significant. Results: The results showed that the polishing technique had a statistically significant mean ΔE than glazing but both were clinically acceptable. Regarding the follow up period results showed that time had no statistically significant effect on mean ΔE values. There was also no statistically significant difference in patient satisfaction within

each technique and at the different follow up times. Conclusion: Although polishing showed higher color change than glazing, it was clinically acceptable. Therefor polishing can be recommended as an alternative to glazing for IPS e.max crowns.

***Keywords*---**color, polish, glaze, lithium disilicate, ceramic.

Introduction

Dental ceramics are widely used as restorative material to replace damaged or lost tooth because of their esthetic properties, as their color, translucency and intensity properties of porcelain materials resemble those of the natural teeth. [1, 2] Various glass-ceramic materials have been promoted and introduced in dentistry, among them lithium disilicate glass ceramic (IPS e-max) which has superior optical and mechanical properties and have been widely used for monolithic ceramic restorations including inlays, onlays, veneers, both anterior and posterior crowns and implant supported crowns. [3, 4]

Surface modifications for ceramic restorations are essential for correcting occlusal interferences and inadequate contours, finishing the margins of ceramic restorations and improving the esthetic appearance. [1] These adjustments resulted in removal of the glazed layer, thus increasing the surface roughness, reducing the amount of reflected light and consequently affect the color of the restoration and increasing extrinsic staining. [5, 6] Therefore, ceramic finishing after the adjustment procedure is mandatory to improve the appearance of the ceramic restorations. [7]

There are two common methods for surface treatment for ceramic restorations, glazing and polishing. Glazing can be created either by firing a transparent glass onto the surface or by heating the restoration up to glazing temperature to get shiny gloss surfaces. While polishing procedures is performed using various diamond points, rubber wheels, and abrasive pastes to give a luster to the surface. [2] When ceramic restoration modifications are performed, the restoration should be sent to the laboratory for reglazing, this process is time consuming and in addition it is not possible to reglaze after the restoration has been cemented in the mouth. As a result, polishing of the adjusted restoration is performed which helps in achieving a smooth surface and increases the fracture toughness of the polished porcelain through elimination of microcracks and surface flaws , moreover polishing has the advantage of being accomplished extraorally as well as intraorally. [8]

Previous studies have compared glazing with different polishing techniques for ceramic restorations regarding surface texture and they demonstrated that polishing could be used as an alternative method for glazing. Other studies investigated the effect of surface treatments on the color of ceramic restorations, according to these studies, surface treatments including glazing and polishing could affect the color of ceramic restorations. [2] An important factor for the clinical success of ceramic restorations is its color stability, worn restorations due to adjustments may be subjected to color changes and create a reason for the

clinician to renew the restorations. [9] With the application of the proper ceramic finishing method color changes and the superficial staining possibility may reduce. [10, 11] Nowadays patients demand for esthetic restorations with long-term color stability increased. [12] Tooth color is one of the most important factors determining satisfaction with dental appearance. Therefore, dentists should consider the esthetic demands of the patients, otherwise patient satisfaction will not be achieved. [13, 14]

Methods

Trial registration and Ethical approval

The protocol of this study was registered on clinical trials with I.D.: NCT03696641. This study and the template informed consent form are reviewed by the Ethics Committee of Scientific Research - Faculty of Dentistry – Cairo University.

Sample size

Based on previous study by Sarikaya et al (2011) [15], a total of 20 crowns, 10 in each group was considered appropriate. The Type I error probability associated with this study was 0.05 and a standard deviation 0.6.

Study design and randomization

The study was a randomized controlled clinical trial, with two parallel groups with 1:1 allocation ratio. The participants were randomly assigned into two groups (n=10), where group A1 represents participants who received polished IPS e.max crowns and group A2 received glazed IPS e.max crowns. Shade measuring and patient satisfaction were evaluated every two months. The participants were randomized by making an opaque sealed envelope containing the grouping performed previously. The patient was asked to choose a paper randomly. The researcher under supervision was responsible of all procedures including patient selection, preparation, shade selection, try in and cementation. The outcome assessors and the participants were blind (double blinding) to the material while the operator (the investigator) was due to the difference in finishing methods and their protocols.

Recruitment

This study was performed in Fixed Prosthodontics Department clinics, Faculty of Dentistry, Cairo University, Egypt. The main investigator selected the patients that satisfy the inclusion criteria from the outpatient clinic of the fixed prosthodontics department – Cairo University.

Eligibility criteria

Twenty patients were selected for this study. Patients' screening and enrollment were performed according to the inclusion criteria including: 1-Patients from 18-50 years old, 2- Psychologically and physically are able to bear conventional

restorative procedures, 3- Have no active pulpal or periodontal diseases, 4- Patients with premolar or molar teeth problems indicated for single posterior crowns and willing to come back for follow-up examinations and evaluation. While the exclusion criteria were: 1- Patient less than 18 or more than 50 years, 2- Patients with partially erupted teeth in the growth stage, 3- Patients with poor motivation and bad oral hygiene, 4- Pregnant women, 5- Psychological problems or unrealistic expectations. These criteria were followed to ensure the success of the proposed treatment plan.

Intervention

Treatment phase started with the diagnostic phase including intra-oral examination, radiographic examination, taking photographs and diagnostic cast formation. Before tooth preparation two intra oral indices were made to determine the amount of tooth reduction and the other for later temporization. Tooth preparation for receiving all ceramic crown was performed using a tapered diamond stone with round end, creating occlusal reduction of 1.5-2 mm and axial reduction of 1.5mm, followed by impression taking and master cast fabrication.

Lithium Disilicate (IPS e-max) crowns fabrication were performed according to the manufacturer's instructions. After finishing of the crowns they were divided into two groups according to the external surface treatment. The first group underwent glaze firing by mixing the glaze powder with e.max glazing liquid (IPS Ivoclar Vivadent, Germany) and an even material was applied on the entire surface of crown then the glaze firing was carried out according to the manufacturer´s instructions. While the second group were submitted to polishing with Eve rotary grinding and polishing kit (Eve rotary polishing kit, Germany)**.** Each specimen was polished with rubbers of three different grains, beginning with the most abrasive one for the pre-polishing, then an intermediate one for polishing and the last, a less abrasive one for high brightness polishing.

A prophylaxis paste and polishing brush was used for cleaning the tooth surfaces prior to bonding to remove any remnants of provisional cements, while The internal surface of the e.max crown was etched for 20 seconds with 9.5% buffered hydrofluoric acid (Dentobond porcelain etch) then the crown was rinsed with water for 20 seconds then air dried. A single coat of the ceramic silane (Dentobond porcelain silane) was then applied and left for 1 minute then air thinned. Finally, the luting resin cement (G-CEM resin cement) was applied to the fitting surfaces of the crown and the crown was cemented to the tooth.

Primary Outcome (Shade measuring)

The color of the final restoration was evaluated using Vita easyshade at the center of the restoration using the ceramic mode immediately after cementation and every two months through one year follow up period. Shade matching was also confirmed with VITA 3D-Master shade guide system.

Secondary Outcome (Patient satisfaction)

The two groups were evaluated every two months up to one year for patient satisfaction about the color of the crown using Visual Analogue Scale (VAS) which is documented in chart including number of satisfied and unsatisfied. The VAS scale ranged from zero to ten where zero means the least satisfaction with color and ten means the maximum color satisfaction.

Statistical Analysis

ANOVA test was used to study the effect of technique, time and their interactions on mean (ΔE) values. Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. Mann-Whitney U test was used to compare between the two techniques. Friedman's test was used to study the changes by time. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0.

Results

The results showed that Technique (regardless of time) had a statistically significant effect on mean ΔE (*P*-value <0.001, Effect size = 0.923). Time (regardless of Technique) had no statistically significant effect on mean ΔE (*P*-value = 0.412, Effect size = 0.092). The interaction between the two variables had no statistically significant effect on mean ΔE (*P*-value = 0.708, Effect size = 0.008). At all follow up times; polishing showed statistically significantly higher mean ΔE than glazing while there was no statistically significant change in mean ΔE values by time (*P*-value = 0.055, Effect size = 0.612) and (*P*-value = 0.072, Effect size = 0.537), respectively. Table (1) Figure (1)

Table (1): The mean, standard deviation (SD) values and results of repeated measures ANOVA test for comparison between ΔE values with different interactions of variables

Time	Polishing		Glazing		*P*-value (Between techniques)	Effect size *(Partial eta squared)*
	Mean	SD	Mean	SD		
Base line	2.4	0.28	1.37	0.19	0.001*	0.863
2 months	2.85	0.45	1.45	0.26	<0.001*	0.882
4 months	2.51	0.4	1.42	0.51	<0.001*	0.733
6 months	2.15	0.07	1.35	0.53	0.009*	0.841
8 months	2.11	0.05	1.3	0.48	<0.001*	0.87
10 months	2.06	0.1	1.31	0.52	<0.001*	0.868
12 months	2.1	0.15	1.28	0.46	0.012*	0.716
P-value (Between times)	0.055		0.072			
Effect size *(Partial eta squared)*	0.612		0.537			

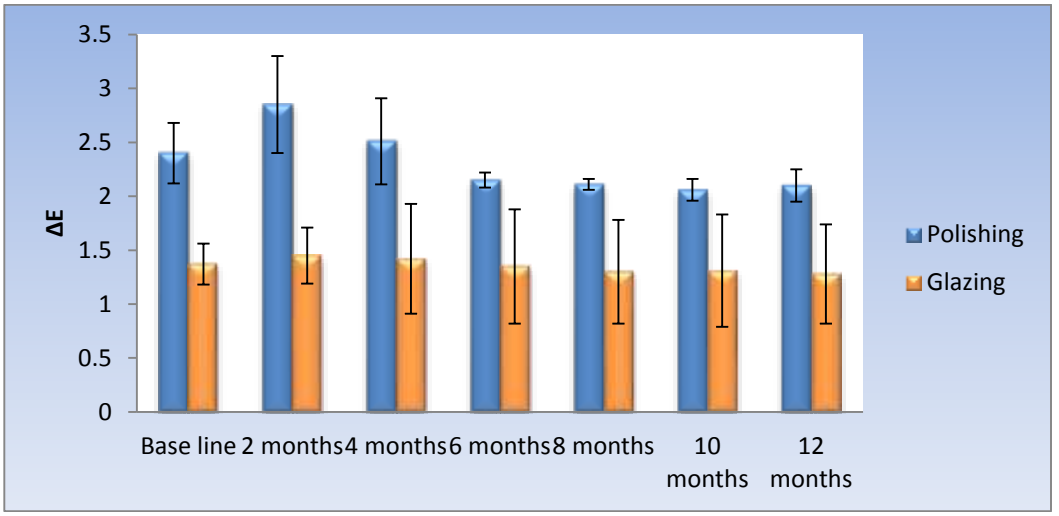

Figure (1): Bar chart representing mean and standard deviation values for ΔE with different interactions of variables

Regarding patient satisfaction, there was no statistically significant difference between the two techniques and also at different follow up times within each technique. Table (2) Figure (2)

Table (2): Descriptive statistics and results of Mann-Whitney U test for comparison between satisfaction scores of the two techniques and Friedman's test for the changes by time within each technique

Time	Polishing		Glazing		*P*-value (Between techniques)	Effect size *(d)*
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)		
Base line	9.42 (0.79)	10 (8-10)	9.58 (0.67)	10 (8-10)	0.615	0.177
2 months	9.33 (0.78)	9.5 (8-10)	9.42 (0.79)	10 (8-10)	0.749	0.118
4 months	9.33 (0.78)	9.5 (8-10)	9.42 (0.79)	10 (8-10)	0.749	0.118
6 months	9.33 (0.78)	9.5 (8-10)	9.42 (0.79)	10 (8-10)	0.749	0.118
8 months	9.33 (0.78)	9.5 (8-10)	9.42 (0.79)	10 (8-10)	0.749	0.118
10 months	9.33 (0.78)	9.5 (8-10)	9.42 (0.79)	10 (8-10)	0.749	0.118
12 months	9.33 (0.78)	9.5 (8-10)	9.42 (0.79)	10 (8-10)	0.749	0.118
P-value (Between times)	0.416		0.075			
Effect size *(ω)*	0.083		0.167			

**: Significant at P ≤ 0.05*

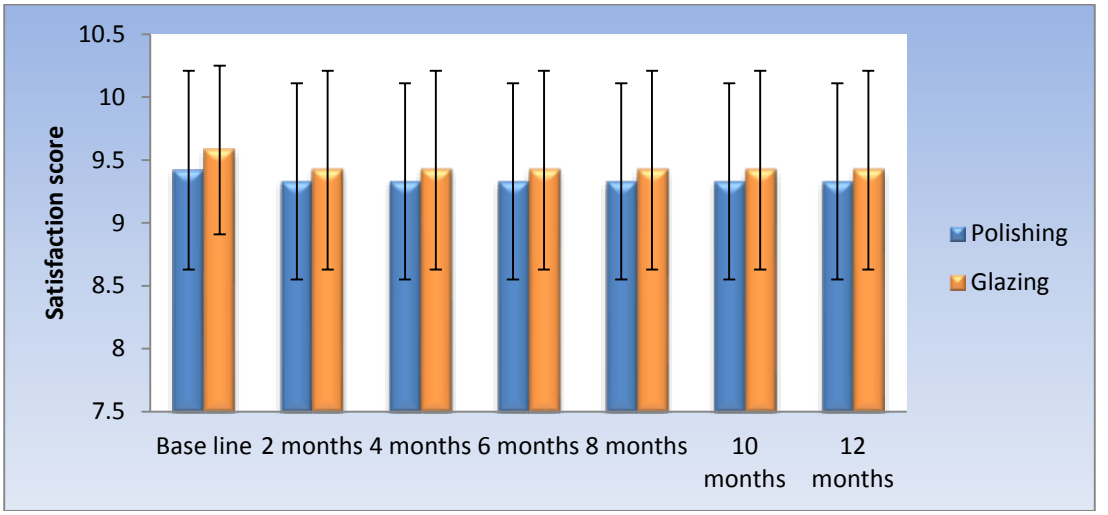

Figure (2): Bar chart representing mean and standard deviation values for satisfaction scores of the two techniques

Discussion

Ceramic restorations are considered to be superior because of their shade matching. Sometimes ceramic restorative surfaces are abraded for occlusal adjustment which results in change in ceramic restorations color. As an alternative to glazing abraded restorations can regain smooth surface through different polishing techniques. Hence, it becomes important to evaluate the effectiveness of various ceramic polishing systems on the color stability of the ceramic restorations. [16, 17]

IPS e-max ceramic is in the focus of interest due to its high translucency and low refractive index. [18] For these reasons Lithium disilicate ceramic were selected for the present study because of their esthetic properties and popularity among dentists. [19] Full coverage preparations were performed by preparing the tooth according to manufacturer's guidelines for IPS e.max crowns. In order to standardize our preparation design the silicon index was used to check the amount of our preparation. [20]

Earlier researchers used to believe that adjusted ceramic should be reglazed only, reglazing has been associated with several disadvantages such as an extra firing cycle may lead to devitrification and can cause color changes. [21, 22] An extra firing cycle may cause also marginal distortion, the reglazed layer wears off easily in a short period of time, an extra appointment is required for the patient, additional time due to the laboratory processing and the impossibility to be made after luting procedures. [23, 24]

Several studies have founded that different chairside ceramic polishing systems have created smooth surfaces as glazing. In addition, chairside polishing of ceramic restorations has many advantages being efficient, easy for the clinician and eliminates repeated laboratory procedures. [25, 24] For these reasons, mechanical finishing methods have been recommended instead of glazing. In

several studies greater correlation have been found between both the objective (spectrophotometer) and the subjective (visual) shade selection methods with respect to color dimensions, it was concluded that instrumental and visual shade matching methods should be combined. [26, 13]

Instrumental shade matching was performed using Vita Easyshade in our study as it has many advantages, it is cordless, small, portable, cost efficient, battery operated, contact-type spectrophotometer and provides enough information to help in the color analysis process. [27] Several studies reported that the VITA Easyshade was the most reliable shade measuring device. [28, 29] Many studies came to a consensus that ΔE values lower than 1.1 cannot be detected by the human eye, while values higher than 3.7 are clinically unacceptable. [30] the results of our study showed that the polishing group had a statistically significant higher mean ΔE than the glazing group but both groups were clinically acceptable, this can be explained as the polishing technique leaves the porcelain surface more porous and rougher which effects color change. [31]

The finding of our current study agreed with the study conducted by Sarac et al. 2006 [1], they found that the polishing technique has a significant higher differences of color change compared to the glazed technique that was attributed to the higher surface roughness of the polished group that reflects light irregularly causing significant color change. Moreover, Patterson et al, 2000 and Wang et al. 2011 [32, 33] found that the smooth surface texture of glazed ceramic reflects greater amount of light compared to the rough surface of the polished group that scatters the light and causes irregular reflection of light and causes changes of the color of restorations.

In addition Al-Wahadni & Martin, 1998 [34] reported that, the glaze procedure sealed the open pores so gave more surface smoothness and better optical properties. While, in the polishing group there was increase in color change due to the presence of surface roughness and flaws that allow the liquids to go through. Motro et al, 2012 [35] found that glazed ceramic revealed higher color stability as the glaze procedure lead to smoother surfaces compared to the polishing system that results in less stain retention. Palla E. et al, 2018 [36] reported that polishing of IPS e-max press produced rough surface that facilitated water penetration and the consequent silica network dissolution, resulting in a reduction of crystallinity and greater absorption of coloring pigments causing color change. On the contrary, the glazed surfaces healed surface irregularities and microcracks, prohibiting water diffusion and subsequent silica network dissolution.

Our findings were in contrast to those studies reported by Ozarslan et al. 2016 [37] and Kilinc H. et al 2018 [11], they found that glazing resulted in significantly higher ΔE than polished ceramics, this could be due to the difference in the ceramics used, as many studies stated that polishing systems can yield different roughness depending on the substrate treated. Similarly Kalia P. et al 2021 [38] found that mechanical polishing of ceramics using pearl finish polishing paste and Soflex discs could produce a surface smoother than the glazed specimens and can produce a color similar to that of glazed porcelain, this can be explained

by the difference in the polishing systems used as they claimed that the polishing pastes have small particle size and able to produce smooth surface.

Regarding follow up time, there was no statistically significant difference between the polished and the glazed groups throughout the study period but with higher ΔE polishing values compared to glazing. This can be attributed to the fact that color stability is affected by surface finishing procedures and surface roughness. [39] Hamza T. et al, 2016 [40] and Prado R. et al, 2017 [41] reported that aging doesn't cause a statistical significant difference in roughness and subsequently color stability is not affected significantly.

The higher ΔE polishing values compared to glazing can be explained by the study of Mirazie M. et al. 2017 [42], they stated that the polishing tools left some voids in the ceramic surface and no such voids were detected in glazed surfaces, leading to more surface roughness and less color stability by aging of the polishing ceramic compared to the glazed one. Concerning patient satisfaction results, all the patients were satisfied with their restorations color and there were no statistically significant differences between the two groups and during the follow up time. This can be explained as the greater ΔE was 2.8 which is below the clinically perceptible value 3.7, as it is very difficult to recognize minor color changes by human eyes in dental materials. [2, 43]

Conclusion

Within limitations of this study, the following can be concluded:

1. Although polishing showed higher color change than glazing, both were within the clinically acceptable limit through the one year follow up.
2. Both surface finishing techniques yielded high patients satisfaction.
3. Polishing can be recommended as an alternative to glazing for IPS e.max crowns.

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