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RESEARCH ARTICLE - MEDICAL TECHNIQUES

Effect of Different Polishing Systems on Surface Roughness of IPS Empress Ceramic Materials

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Abstract

For evaluation and comparison of the effect of surface treatment (glazings, polishing with rubber wheel and diamond paste, and polishing with rubber wheel) on pressable porcelain (IPS Emax porcelain) surface roughness in comparison with non-treated surface. Forty-disc shaped specimens of baseplate wax with 10 mm diameter and 2 mm thickness have been prepared. They were invested and subjected to lost wax technique in fabricate the pressable ceramic. Following pressing, they have been divided randomly into four groups: Group A: no surface treatments, Group B: glazing (paste, HT, Ivoclar, Vivadent, Germany) glazing (paste, HT, Ivoclar, Vivadent, Germany), Group C: polishing with burs (DIAPRO TWIST, EVE, GmbH, Germany), and Group D: polishing with burs (DIAPRO TWIST, EVE, GmbH, Germany) and diamond paste (All in one, RENFERT, GmbH, Germany). For each specimen, examination of mean roughness profile (Ra) was performed for total surface roughness description. Specimens were stabilized with the acrylic holder used previously in the initial polishing procedure. A contact stylus profilometer was used to conduct a quantitative measurement of surface roughness in micrometers (µm) for all specimens. The highest (Ra) value was for control group (1.9520), whereas the lowest values were in group D (Polishing by rubber wheel .4670. One-way ANOVA test showed a high significant value at (P <. 000), and LSD test showed a high significant value at (P <. 000) when comparison was established among groups. From the results of the current study, we can conclude the following; polishing procedure for the surface of pressable ceramic with or without diamond paste produced better surface smoothness than glazed surface and non-treated surface and polishing with burs could be an alternative to glazing to provide smooth surface.

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Keywords: Pressable Ceramic; Surface Roughness; Profilometer; Glazing.

1. Introduction

All-ceramic restorations have become appropriate alternatives to metal restoration due to their excellent biocompatible characteristics and high aesthetic performance to the veneering porcelain fused on ceramic substrates [1]. It is believed that ceramics are superior to the beauty of form reproduction and in the harmonious blend of colors and shades [2], all-ceramic restorations were fabricated by several methods. Among these methods, the heat pressing method was a well-founded one with the aid of the lost-wax procedure [3]. The heat pressing method involves concurrent heat and pressure application of pre-fabricated ingots in a pre-invested mold cavity that was utilized in dentistry for more than for the fabrication of partial fixed dental prostheses and single crowns [4]. The material's surface smoothness significantly affects the reduction of bacterial accumulation, and it can be indicated that a smooth surface leads to a reduction in bacterial adhesion [5].

During ceramic restoration fabrication or chairside adjustment, surface roughness can be increased. The ceramic restoration glazing is a laboratory method which results in pore sealing on the fired ceramic surfaces. A ceramic glaze consists of a mixture between a powder and a liquid fired on the surface of ceramics, leading to glossy surfaces [6]. Clinicians usually attempt to select the best suitable materials and finishing processes because of the wide ceramic material selections available in the market [7]. The glazing of the ceramic restorations leads to pores sealing on the surface of the fired ceramic, leading to a glossy finish. The glaze layer is indicated as a protective layer for stain prevention, wear and color alterations. Glazing is carried out through using a thin layer of clear glasses to surface of the porcelain either applied as drops or creamy mixture on porcelain surface. Sometimes auto-glazing could be performed by heating porcelain inside the furnace for (1-2) min. to obtain surfaces of shining glasses [8]. This study aimed to measure the effect of different polishing techniques on the surface roughness of pressable porcelain.

2. Material and Methods

2.1. Preparation of specimens

Thirty disc shaped heat pressed ceramics have been fabricated of the wax patterns. A modeling base plate wax sheet (2mm thick) was used in this study for the specimens' fabrication. A copper ring, 10mm in diameter (NO.15, Lot no.15039, Germany), was used for the specimen production.

Nomenclature & Symbols			
°C	Centigrade	Sec.	Second
Ra	Surface Roughness	Rpm	Rotation per Minute
Min.	Minute		

Investing of wax patterns specimens: Investment powder was mixed with a special liquid (IPS Press Vest for different press ceramics, Ivoclars, Vivadents AG, FL-9494 Scha'an Lichtenstein, Germany) following the guidelines of the manufacturer. The mixture was poured into the casting ring and the material was left on a bench for setting procedure according to manufacturer's instructions.

2.2. Burnout of wax pattern specimens

This procedure was performed in a specially programmed electrical furnace (Maxwell, MTA-96). The set investment materials were pushed out of the IPS Silicon rings and placed inside the burn-out furnace. The investment ring was removed from the furnace at once after the burn-out procedure was completed according to the manufacturer's instructions.

2.3. Pressing procedure

IPS E.max Press ingot (IPS E.max press LTA1, Lot no. S17693, Ivoclarvivadent, Liechtenstien, Germany) was out in a hot investments ring, and the procedure of pressing was established inside the porcelain furnaces (Computerized porcelain furnaces for pressable ceramics (Programat. EP. 3000, Ivoclars - Vivadent, Germany). At the time of press cycle completion, the investment rings were put on cooling grids and left to cool.

2.4. Divesting procedure

This procedure was established with the aid of a sandblast machine and 50μm air-born particles; the pressure used was 0.2 MPa for 10 seconds for the divesting procedure. A diamond cutting wheel and a diamond cutting saw were used for the separation of sprues from the specimens. Then the specimens were cleaned from any remnants of dust or oil using a steam jet cleaner according to the manufacturer's instructions.

To standardize, each sample's surface was been flatted and levelled by the use of grinder/polisher devices with silicon carbide paper (1200) grit for (10) sec. under water cooling and then cleaned with distilled water [9]. The papers were replaced after grinding every eight samples to maintain a consistent amount of grit [10].

2.5. Specimen grouping

The specimens were randomly divided into four groups according to surface treatment applied, with 10 specimens in each

- Group A: no surface treatment; the specimens were not subjected to any surface treatment.
- Group B (Glazing): Two coats of glaze material (paste, HT, IVoclar, Vivadent, Germany) in a creamy consistency that applied on each specimen, and then sintering was performed in an electrically programmed porcelain furnace at 770 °C (EP 3010, Ivoclar,Vivadent, Germany) according to manufacturer's instructions. As shown in Fig. 1.
- Group C: (polishing with burs with paste): first, polishing was performed the same as group A, followed by the use of RENFERT polish (All in one, RENFERT, GmbH, Germany). They were applied for 30 seconds with the aid a of cotton brush. This was accomplished in one direction by using a straight hand piece (W& H, USA), rotating at 30.000 rpm as in Fig. 2.
- Group D (Polishing with burs): (DIAPRO TWIST, EVE, GmbH, Germany), and polishing step consisted of using a polishing kit of two steps: pre–polishing burs followed by high shine polishing bur. This was accomplished in one direction by using a hand piece (W& H, USA) rotating at 30.000 rpm. This step was accomplished by the same operator to ensure standardization, as in Fig. 3. (According to the manufacturer's instructions).

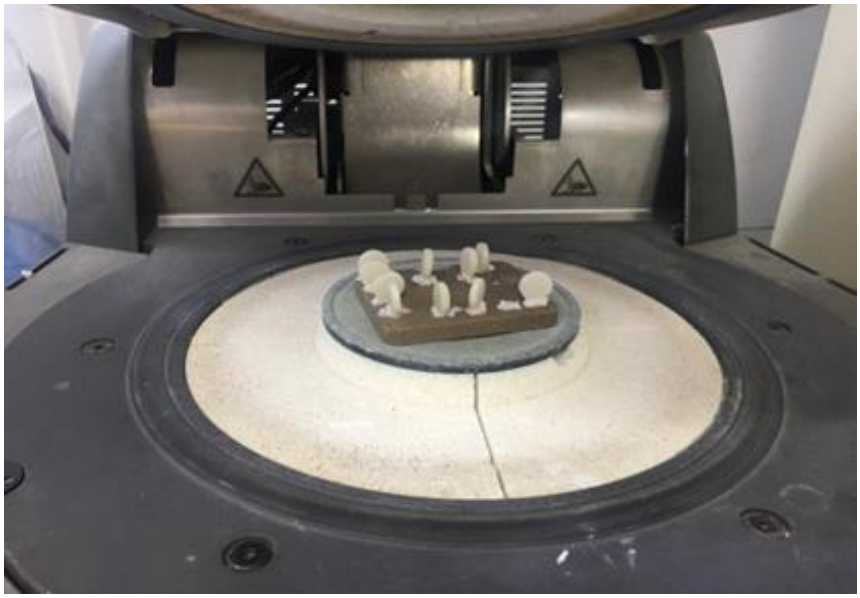

Fig. 1. Glazed specimens

Fig. 2. Polishing ceramic surface with diamond paste and burs

Fig. 3. Polishing ceramic surface with rubber wheel polishing burs

2.6. Ultrasonic cleaning of specimens

After the end of the surface treatments, all the specimens were ultrasonically washed in cold distilled water using an ultrasonic cleaning machine for 10 minutes before measuring the surface roughness [11]. For all samples, mean roughness profiles (Ra) were examined for a description of the total surface's roughness. The specimens were stabilized with the acrylic holder used previously in the initial polishing procedure. A contact stylus profilometer (Fig. 4) was used to conduct a quantitative measurement of surface roughness in micrometers (µm) for all specimens. Three readings parallel with each other were done on the center of each disc specimen, and a calculation of mean Ra was done to find the general surface properties of the samples [12]. Data collected were statistically analyzed by SPSS software 21. Mean, SD, Maximum, Minimum, One Way – ANOVA tests to determine if there will be statistically significant difference among group, and LSD (Least Significant Difference) test will be performed to determine the source of variance.

Fig. 4. Profilometer used for measuring surface roughness of ceramic

3. Result

Descriptive statistics of surface roughness values (Ra) included mean, standard deviations as well as maximum and minimum values for each studied group as demonstrated in Table 1.

Table 1. The descriptive statistics of surface roughness values (Ra) of studied groups

Surface treatment	Group	Mean	SD	Min.	Max.
Control	A	1.9520	.02700	1.90	1.98
Glazing	B	1.5430	.03802	1.50	1.59
Polish with rubber wheel and paste	C	.9720	.02098	.92	.99
Polish with rubber wheel	D	.4670	.06165	.41	.59

Table 1 revealed that the higher mean value for surface roughness was in group (A), whereas the lowest mean value of surface roughness was in group (D). The test of One-way analysis of variance (ANOVA) was carried out to evaluate the presence of any statistically significant differences between mean values in the four groups of surface treatment as illustrated in Table 2.

Table 2. One-way ANOVA test for surface roughness values (Ra) for all groups

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.679	3	4.226	2635.131	.000(HS)
Within Groups	.058	36	.002		
Total	12.737	39			

*P<0.000 High significant.

In accordance with the findings in Table 2, the one-way - ANOVA showed highly significant differences in surface roughness values among all the groups (P=0. 000).

The LSD (Least significant difference) tests were performed to locate variance sources in the groups as illustrated in Table 3.

Table 3. LSD testing among the groups

Groups	Mean Difference (I-J)	P-Value	Sig.
Group A	B	.40900*	000
	C	.98000*	000
	D	1.48500*	000
Group B	C	.57100*	000
	D	1.07600*	000
Group C	D	.50500*	000

*P<0.000 High significant.

4. Discussion

The occlusal adjustments of ceramic restoration include glazing or polishing of ceramic surface. For prevention of excessive wear of opposing teeth and minimizing plaque accumulations, the smoothed ceramic surface prevents excessive wear- off. The ceramic surface roughness is an important factor that affects wear [14]. Furthermore, wear of the opposing material was highly correlated with the surface roughness of the ceramic material [15].

For a description of the porcelain specimen surface texture following different surface treatments applied for the three tested groups, Ra parameters obtained with a profilometer are used. It provides a description of the whole surface roughness and is defined as arithmetical mean values of the whole roughness profile absolute distance from the centre line within the measurement lengths [16].

The highest value of surface roughness was in the controls while the lowest was in the polishing with rubber wheel group. This could be explained by the fact that the control group was not subjected to any surface treatment following divesting after the pressing procedure, and the greatest value in surface roughness could be attributed to the fact that during divesting, all specimens were subjected to air abrasion particles (50 μm) to remove investment debris. These results agreed with Mohammed et al. 2016 [17].

In the present study, polishing groups produced the lowest surface roughness value. This result is in agreement with Sarikaya and Guler, 2010 [16]; these investigations stated that polishing was an effective method for reducing the surface roughness of pressable ceramic.

Regarding the glazing and polishing procedure, the glazing procedure in this study showed that the surface roughness increased significantly in comparison with the polishing group and polishings with diamond pastes, but it showed a significant decrease in surface roughness in comparison with the control group. This result could be attributed to the fact that the glazing aimed at sealing the open surface pore at the surfaces of fired porcelains, thus decreasing its surface roughness and decreasing light scattering [18]. This result is in agreement with the results of El-Etreby, 2017, a study showed that glazing reduced surface roughness in comparison with non-treated surfaces, and this result coincide with the results of Vasiliu et al. 2020 [6] and Çakmak et al. 2021 [19]. This decrease in the value of surface roughness can be achieved from combining the compressive residual stress and removing the large surface flaws produced during processing. During polishing and grinding procedures, larger flaws produced during fabrication can be removed; therefore, certain flaws that may become cracks are removed for the purpose of fracture resistance increasing [20]. Since abrasion contacts the material's surface, compressive stress can be produced affecting flaws directed perpendicularly and parallel to the surfaces, but depends on the polishing process parameters. There may be an overlap of the compressive stress area beneath all abrasive particles, forming a compression layer. The resulting stress state and surface finish will mainly affect the material's mechanical properties. After polishing, residual compressive stress was shown to happen in a great number of ceramic substances [21]. The surface compression layer can be carried out by thermal tempering, polishing, and machining with glazing layer application with a less coefficient of thermal expansions than adjacent ceramic materials [17]. However, the results of the present study disagree with those of Aldosari et al. 2021 [22]. This disagreement could be attributed to the differences in the brand of lithium disilicate used and the differences in the polishing kit between the two studies.

In the current study, glazing did not result in minimizing of surface roughness as efficiently as polishing, and this can be because coating layer was not adequately thick for the completion of the grooves and micro-cracks of ceramic effectively as stated by (Azez and Salih, 2019; Hashim and Mansoor, 2021), [23, 24].

5. Conclusion

In accordance with the results of the present study, it can be conclude that the polishing procedure for the surface of the pressable ceramic with or without diamond paste produced better surface smoothness than glazed surface than the non-treated surface and polishing with burs could be an alternative to glazing to provide a smooth surface because of the ability of the polishing procedure to remove any irregularities on the porcelain surface.

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