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Effect of Polishing Systems on Mechanical Properties of Emax Press Restorations

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Abstract
This study aimed to evaluate the impact of surface treatment (polishing, polishing with diamond paste and glazing) on the Vickers microhardness of pressable ceramics IPS Emax porcelain in comparison with non-treated surface. Materials and Methods: Forty disc shaped samples of baseplate wax with 10 mm diameter and 2 mm thickness have been prepared. They were invested and lost wax technique was performed to fabricate the pressable ceramic. Following pressing, they were divided randomly into four groups (n=10): Group A: no surface treatment, 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 diamond paste (All in one, RENFERT, GmbH, Germany), and Group D: polishing with burs (DIAPRO TWIST,EVE, GmbH, Germany). For all specimens, the Vickers hardness number (VHN) was determined using a digital tester. Vickers hardness was used in this analysis due to the small specimen size and multiple compositions. Each specimen was put on the device's stage, the Vickers indenter was then lowered slowly until it came into contact with the polished surface of the specimen. Results: The highest Vickers Hardness Number was for polishing with burs and diamond paste and polishing with burs, while the lowest Vickers Hardness Number was for control group. One-way ANOVA test showed a high significant difference at $P < .000$. LSD test reviled there was non-significant difference between polishing with burs and polishing with burs and diamond paste. Conclusions: Within the limitation of the present study, it can be concluded that, polishing can considered as an effective method as glazing to improve surface hardness of pressable ceramic, and polishing with or without diamond paste can be an effective method to improve surface hardness.

Introduction:

Ceramic crowns and veneers are the most esthetically pleasing prosthodontic restorations. They resemble natural structures of teeth since there is no metal can block light transmissions, and they are better than other restorative options in regard to translucency and color [(1).] Before 20 years, the glass ceramics of Lithium disilicate (LS2) have been used in dentistries [(2)]. After convenient heating of the parent glasses of such materials, there will be a precipitation of lithium phosphate nanophase (Li3PO4) which will function as catalysts for lithium metasilicate (LS) to be heterogeneously nucleated, synchronously with LS2 crystal formation [(3).] Consequently, the ultimate microstructure consists of ~70 vol% crystalline phases, as LS2 will be the primary phase. [(4)] Lithium disilicate glass ceramic seems the toughest and strongest in all glass ceramic. It is suggested for anterior and posterior single crowns, for bridges anterior to second premolar and for implanting super structure [(5)]. Many factors directly affected the long term clinical successes of dental ceramics including ceramic materials of the crystal-based microstructures, the fabrication processes of these materials, technology and clinical environments. The ceramic materials can be negatively influenced by these steps owing to their brittle behaviors. The material's strength is affected by the size, shape and amplitude of the internal and external defects [(6).] The final structure of the ceramic restoration can be flawed by certain factors as well as the heat-pressing procedures [(7).] During the firing process, some defects like cracks around grains and porosities may develop. There may be an association between the microcrack's distribution and the deterioration of several ceramic materials. These microcracks can be induced by the finishing procedures [(6)] Ceramics are characterized by chemical inertness, hardness, refractory nature, biocompatibility and susceptibility to brittle fracture. [(5)] Hardness is a characteristic feature of The solid materials is characterized by hardness which expresses their resistance to permanent deformations [(1)] Measuring dental material hardness is essential because of its delineating the material's abrasiveness to which natural dentitions can be submitted. [(8)] Methods of surface finishing involve polishing by adjustment kits and diamond polishing paste in addition to glazing. Among the typical practices is using the diamond polishing paste to polish porcelains. Such a paste gives an excellent polishing result. [(9).] The refreshing method can impair the physical and mechanical strength of ceramic restorations because of the microcrack formations and may be more sensitive to a later serious fracture [(8)] The processing methods and/or clinical adjustments may lead to a subcritical flaw or a large defect which, upon existence of moistures and/or clinical loadings, can develop to a serious condition resulting in a catastrophic failure. It measures resistances to plastic deformations, and it is calculated as a force/unit indentation areas, therefore, its measuring is of importance in dentistry[.(10)]

Material And Methods:

Preparation of specimens: Forty disc shaped heat pressed ceramic were fabricated from wax pattern. In this study, the wax pattern was produced with aid of a (2 mm thick) modeling base plate wax sheet. A 10 mm diameter copper ring (NO.15, Lot no.15039, Germany) was used to punch the modeling baseplate wax pattern and produce the wax pattern specimen. The wax pattern specimen investment: The investing powder was mixed with a special liquid (IPS Press Vest for various press ceramics, Ivoclaar, Vivadents AG, FL-9494 Schan Liechtenstien, Germany) following the guidelines of the manufacturer. The mixture was poured into a casting ring then the material was left on a bench for setting procedure according to manufacturer's instructions. Burn out of wax pattern specimens: This procedure was performed in aspecially programmed electrical furnace (Maxwell, MTA-96). The set investment material has been pushed out of the IPS Silicone rings, and it was placed inside the burn out furnace. Following the completion of the procedure of burn out, and then investment rings were immediately taken off the furnace. Pressing procedure: IPS e. max press ingot (IPS e. max press LTA1,Lot no.S17693,Ivoclarvivadent,Liechtenstien, Germany) was put in a hot investing ring, and the procedure of pressing was established in the (Computerized porcelain furnaces for the press able ceramics (Programat EP 3000, Ivoclar, Vivodent, Germany). During press cycle completion, an investment ring is put on the cooling grid and left for cooling. 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 divesting procedure. A diamond cutting wheel and a diamond cutting saw were used for separation of sprues from the specimens. Then the specimens were cleaned from any remnants of dust or oil using steam jet cleaner. In order to establish standardization for all specimens, the surfaces of the specimens were flatted and leveled with the use of grinder/polisher devices with silicon carbide paper (1200) grit for (10) sec. under water cooling. After that, each specimen was cleaned with DW .[(11)] The papers were replaced after grinding of every eight samples to maintain a consistent amount of grit.[(12)] Specimen grouping: Samples were divided into four groups, ten specimens in each one, in accordance with the following surface treatments:

1.Group A (No surface treatment). In this group no treatment was established on the surface of the specimens.

2. Group B (Glazing): Two coats of glaze material (paste, HT, Ivoclar,Vivadent, Germany) in creamy consistency have been placed on each specimen, then the sintering was performed in electrically programmed porcelain furnace at 770C° (EP 3010, Ivoclar,Vivadent, Germany) according to manufacturer's instructions as shown in figure 1.

3. 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 of cotton brush. This was accomplished in one direction by using hand piece (W& H, USA), rotating in 30.000 rpm as in figure 2.
This step was accomplished by the same operator to ensure standardization.

4.Group D (Polishing with burs) : (DIAPRO TWIST,EVE, GmbH, Germany), and polishing step consisted of using polishing kit of two steps: pre – polishing burs followed by high shine polishing bu. This was accomplished in one direction by using hand piece (W& H, USA) rotating in 30.000 rpm. This step was accomplished by the same operator to ensure standardization, as in figure 3

After the end of surface treatments, all the specimens were ultrasonically washed in cold distilled water using an ultrasonic cleaning machine for 10 minutes. [(13)]

Hardness test.
For all high-luster polished specimens, the Vickers hardness number (VHN) was determined using a digital tester. Vickers hardness was used in this analysis due to the small specimen size and multiple compositions. Each specimen was put on the device's stage, the Vickers indenter was then lowered slowly until it came into contact with the polished surface of the specimen. The Vickers hardness testing involves indenting samples using the diamond indenter-shaped similar to a right pyramid with a square base and 136˚ degree angles between the opposite side. The dots of the indentation remaining in the surface of the specimen after the load has been released automatically and determined microscopically with calculation of the average estimated area of the indentation sloping surface.

Results:

The descriptive statistics of Vickers Hardness Number values (VHN) which included means, standard deviations as well as maximum and minimum values of each veneered group as illustrated in the table (1). Table (1) showed that the highest mean value of Vickers Hardness Number was in the group (C), whereas the lowest mean value of Vickers Hardness Number was in the group (A). The test of one way analysis of variance (ANOVA) was performed for assessment of mean value significant variations between the four groups of surface treatments as demonstrated in the table (2). In accordance with the results in the table (2), the ANOVA test revealed a statistical high significant variation in Vickers Hardness Number among all groups (P=. 000). The source of variance between the groups was located using the LSD test as observed in the table (3). From the table (3), there is high significant difference among all groups and at p<.000, but there is non-significant difference when comparing between group C and group D.

Discussions:

The most effective methods for yielding higher glosses and minimizing roughness as well as minimizing surface scratches are glazing or manual finishing and polishing methods .[(14).] The surface hardness is defined as the relative measurement of resistance to successive indentations. Indentations have direct impacts on the material's capacity to be polished, and they also have influences on the material's resistance to occlusal wears .[(15)] Vickers indenters are widely used among various indenter geometries used in hardness testing. The test of Vicker Hardness was applied since it is appropriate to determine the small area hardness as previously used by many investigators .[(11).] Due to the recommendations of Ivoclar companies for IPS e – Max press ceramics polishing, Rubber wheel burs have been used, and a maechanical polish of ceramics by rubber wheel have been suggested, particularly in limited-access areas like areas of occlusal surfaces of the posterior teeth.[(16)]. The microstructure influenced the surface roughness and the mechanical characteristics of ceramics particularly the crystalline phases.[(9)] In this study, the highest Vickers microhardness number was found in the polished groups with diamond paste & polished group with bur, and the lowest was for the control group. When comparison by statistical analysis among groups was performed, there was a very high significant difference among group. The control group showed a reduction in microhardness number regarding the glazing group. These results agreed with Mohammed *et. al*, 2015.[(18)] who revealed that glazing improved surface hardness better than non-treated group. Such a finding may be explained according to surfaces compressive stresses. Because glazes are located on porcelain's surfaces, a compressive stress will be generated when the underlying ceramics contract more in case of cooling for placing surface glazes in compression. Those surface compressive stresses may lead to appreciable strengthenings through crack growths inhibition from surfaces via porcelain's bodies [(18)] In the glazed group, the increased VHN attributed to crystalline structures of IPS e – max press ceramics. The controlled crystallization method was used to produce it, where the crystalline phase (Lithium disilicate $Li_2Si_2O_5$) is nucleated and grown inside a glass via heating treatments. The elongated interlocked crystal form 65% of glass ceramic microstructures 10 IPS e. max Lithium disilicate consists of lithium dioxides, quartz, phosphor oxides, alumina, potassium oxides as well as other constituents. Such compositions result in the production of a glass ceramic with highly thermal and shock resistance due to the low thermal expansions that occur during processing procedure.[(17)] There was a high significant difference between polished group and glazed group. This finding agreed with the results by Vasiliu *et al*, 2020.[(9)] who proved that polished lithium disilicate ceramic showed a higher microhardness number glazed group, This finding may also related to the fabrication technology as during the pressing step, the e. max press is softened via heating, followed by the removal of reaction layers then undergone heat treatments.[(10)] The lithium disilicate glass ceramic pressing is a process of highly plastic deformations which may cause a crystal alignment within the alignment parallels to the pressing directions, which may be explained by a VHN increase [17] In the current study, there was a non-significant difference when comparing between polished group with burs and polished group with bur and diamond paste. This result may be explained by the low diamond contents and high silicon carbide contents of the polisher used with the paste in comparison with the current polishing kit. [19]

Conclusion

From the current study, it can be concluded that polishing can considered as an effective method as glazing to improve surface hardness of pressable ceramic, and polishing with or without diamond paste can be an effective method to improve surface hardness.

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Figure 1 glazing paste

Figure 2 polishing burs with diamond paste

Figure 3: Polishing burs

Table 1. Descriptive Statistics of Vickers Hardness Number values (VHN) values of studied groups

Surface treatment	GROUPS	Mean	SD	Min.	Max.
control	Group A	82.4320	.91628	81.30	83.90
Glaze	Group B	92.0900	1.05667	90.00	93.10
Rubber wheel with past	Group C	95.5800	.42635	95.00	96.20
Rubber wheel	Group D	95.2600	.97091	94.00	96.60

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Table 2. One-way ANOVA test for Vickers Hardness Number values for all groups.

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1132.590	3	377.530	490.207	.000(HS)
Within Groups	27.725	36	.770		
Total	1160.315	39			

*P<0.000 High significant

Table 3. LSD test among groups

Groups		Mean Difference (I-J)	P-Value	Sig.
Group A	B	-9.65800-*	000	(HS)
	C	-13.14800-*	000	.(HS)
	D	-12.82800-*	000	.(HS)
Group B	C	-3.49000-*	000	.(HS)
	D	-3.17000-*	000	.(HS)
Group C	D	-.32000-	.420	(NS)

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