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Comparison of Polishing and Overglazing Effect on Fracture Load of Machinable Feldespathic Ceramics (Vita Mark II)

Abstract

Nowadays, there is little information about the effect of surface polishing and glazing on the fracture strength of ceramic restorations made with CAD/CAM. Also, due to the contradictions in the available information and the shortcomings in previous studies in this field, this research aims to compare the fracture load of ceramic restorations made of CAD/CAM blocks (vita Mark II) after overglazing and polishing. The purpose of this study is to compare the effects of polishing and overglazing on the fracture load of Vita Mark II machinable feldspathic porcelain. The prepared model was scanned by a laboratory scanner, and 20 composite resin dies were made from it by CAD/CAM. 20 feldspathic crowns were made for the dies by the CAD/CAM system. The crowns were divided into two groups. One group was polished, and the other was overglazed. The cemented crowns were kept for 1 week in normal saline, and their breaking force was measured and statistically analyzed. The findings were analyzed by a T-test. A distinct difference was observed between the studied groups (P = 0.004). According to the T-test, the fracture force of the polished group was significantly higher than that of the overglazed group. Based on the results of this study, polished coatings had higher fracture resistance than overglazed coatings. Although the overglazed surface was smoother than the polished one, its strength was lower, which indicated that the fracture resistance was dependent on the internal structure of the material.

Keywords: *Fracture Load, Feldespathic Ceramics, Metal-ceramic, Polishing, Overglazing*

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Background

Metal-ceramic restorations provide the necessary strength for a restoration due to having a metal substructure, but they have defects such as opsite, an opaque appearance, and a black line at the edge of the gum (1). Due to the increase in aesthetic needs, all-ceramic restorations were introduced (2). These materials have good biocompatibility and good aesthetics, but their fragility as well as their high susceptibility to defects such as microcracks have limited their use in areas with low stress (5, 4, 3). Dental ceramics are inherently brittle in tension; therefore, fracture is always a major concern for all-ceramic restorations (2). Among all ceramic materials are feldspathic porcelains. These materials have excellent biocompatibility. Plus, in terms of beauty, they are at a desirable level. Among the disadvantages of these materials are their fragility and low tensile strength (6).

Vita Mark II blocks, which are feldspathic porcelains, have been available since 1991. These materials are one of the most wear-resistant dental ceramics. Also, the clinical survival rate of these materials is almost 95%. Their abrasiveness is very similar to natural enamel, so the abrasive effects on the opposite teeth are reduced. Also, these materials provide a reliable adhesive connection with the tooth. Their high translucency also makes them excellent in most clinical situations (7).

Due to the low tensile strength of feldspathic porcelain (60–70 MPa), a metal substructure is used in metal-ceramic restorations, but in all-ceramic feldspathic restorations, alternative methods must be used to strengthen these materials. One of the methods of strengthening porcelain is by creating compressive stress on the surface of feldspathic porcelain, which can be created through methods such as glazing, ion exchange, etc. (6). Sometimes all-ceramic materials must be clinically adjusted to match the occlusion. As a result, they need clinical polishing.

In some studies, it has been stated that glazing improves the strength of ceramic materials and reduces surface roughness (8, 18–20). Also, some authors have stated that the strengthening caused by glazing causes a decrease in the depth of surface cracks and prostheses (2), but in some other studies, it has been reported that glazing does not affect the strength of ceramic materials (20, 21). In most of the studies where polished porcelain has been compared with auto glazed and overglazed ones, the surface roughness of porcelain has been discussed (8, 12, 22), and in a few studies, the effect of polishing on the strength of porcelain has been investigated. The physical characteristics of all ceramic restorations are not only dependent on the manufacturing process (including condensation, melting, and sintering) but also, on the level of skill and accuracy of the technician (23).

Today, there is little information about the effect of surface polishing and glazing on the fracture strength of ceramic restorations made with CAD/CAM (26). Also, due to the contradictions in the available information and the shortcomings of previous studies in this field, this research aims to compare the fracture load of ceramic restorations made of CAD/CAM blocks (vita Mark II) after overglazing and polishing.

Methods

In this experimental study, an upper first molar on a typodont model (Vita, Bad Sackingen, Germany) was prepared by a turbine (NSK PA-T-B2, Tokyo, Japan) with sufficient water spray for all-ceramic coating. The shaved model was scanned by a laboratory scanner (3Shape, TRIOS3, Copenhagen, Denmark).

20 resin composite dies (Hipc, Brezent, Germany) were made from this prepared model by a laboratory CAD/CAM machine (Imes Icore 450i, GmbH, Eiterfeld, Germany). One of the resin dies was scanned by a laboratory scanner (Sirona Dental System, GmbH Bensheim, Erlangen, Germany). 20 all-ceramic crowns made of feldspathic porcelain vita mark II (Vita, Bad Sackingen, Germany) were made according to it using CAD/CAM technology (Sirona Dental System GmbH, Bensheim, Germany). The occlusal was prepared to morphologically accept the force of a sphere with a diameter of 3 mm (33).

Twenty samples were randomly divided into two equal groups.

First group: In this group, the crowns were overglazed (in these crowns, the sprue was first removed by a 40-micron diamond bur for Vita porcelain and then an 8-micron diamond bur and polished with flexible discs, and then overglazing was done).

Second group: In this group, the crowns were polished.

In the first group, by placing a special glaze liquid (Vita shade liquid, Bad Sackingen, Germany) on each sample according to the factory instructions, the samples were overglazed in a porcelain furnace (Vita vaccumat 200, Germany) as follows:

First, they were placed in pre-heat conditions for 6 minutes, and then the furnace temperature reached the final temperature of 950 degrees Celsius at a rate of 58 degrees Celsius per minute and kept at this temperature for 1 minute (34).

In the second group, the Vita porcelain polishing set (Vita Zahnfabrik Bad Sackingen, Germany) was used for polishing according to the factory's instructions, so first a 40-micron diamond bur was used for polishing and then an 8-micron diamond bur was used in the next step. Flexible disks covered with aluminum oxide were used, and in the last step, the diamond polishing paste was used, so that finally a completely shiny and lively surface was created on the porcelain (35).

Before cementation, each crown was placed on its corresponding die model to check the marginal fit. A stereomicroscope (HP SMP-320, Taiwan) was used to determine the margin gap at three points (middle and near the two parasite lines) on each level. Each crown was removed with an average margin gap greater than 100 µm.

The crowns were cemented with panaviaf2 resin cement (Kuraray, Japan) according to the manufacturer's instructions, so first the crowns were etched with 9.6% hydrofluoric acid (Pulpdent Corporation, USA) for 90 seconds, then gently washed and dried.

Then Silen (Pulpdent Corporation, USA) was applied in such a way that one layer was applied first, and after drying, the second layer was applied and allowed to dry. For cementation, the surfaces of the dies were etched with 37% phosphoric acid (Meta Etchant, Korea) for 15 seconds. Etched surfaces were washed with water spray for 20 seconds and dried with oil-free air spray.

First, bonding (3M ESPE, USA) was applied to the etched dies, and it was slowly dried. After putting cement inside them, the coatings were placed on their corresponding die models with finger pressure, and the excess cement was removed. Then, the crowns cemented with Panavia f2 cement (Japan, Kuraray) were first exposed to light for 5 seconds by a light cure device (Woodpecker LED, USA), and the cement additions were removed, and then each surface was irradiated for 20 seconds for each surface (4 levels). Vaseline was used on the finish line of the lathe to prevent oxygen from reaching the crowns (36).

The dimensions of each sample were measured from the occlusal surface of the crown to the apical surface of the model before and after cementing to confirm the seating of the crown with a digital caliper (Digital Caliper 150mm, China) with an accuracy of 0.01 mm (10 microns). None of the samples should have an increase in vertical dimensions of more than 100 µm.

The samples were kept in normal saline (Sodium Chloride 0.9%, Daru Pakhsh, Iran) at a temperature of 37 degrees Celsius for one week. All the cemented crowns were mounted with their respective dies in self-hardening resin material (Meliodent, Hanu, Germany) (10).

All coatings were subjected to a failure test by a universal testing machine (Zwing, Germany) using a load cell at a speed of 1 mm/min. In this way, a stainless steel ball with a diameter of 3 mm was placed on the depression area that had already been created on the coating.

The force at the time of breaking (in Newtons) was recorded, and then the amount of breaking force of the crowns was compared and evaluated (37). One randomly broken sample from each group was examined by SEM (LEO, 1455VP, Germany). The data was analyzed using SPSS 20 software and a t-test.

Data Analysis

A t-test was used for data analysis, which was done with SPSS software, version 20. The T-test was used to compare the mean values of the variables (two types of surface preparation of the samples). It is also appropriate to use descriptive statistical tables and statistical charts to express variables.

Results

In this research, the fracture resistance of Vita Mark II feldspathic porcelain was investigated in two groups: overglazing and polishing. The fracture strength in the polishing group was 978 ± 1.222 N, and in the overglazing node, it was 723.2 ± 139.93. Based on the T-test, the average findings of the two groups were significantly different ($P < 0.05$) (Table 1). The average data of the polishing group was higher than the overglazing one ($P = 0.004$), which shows that the polishing group has higher fracture resistance than the overglazing one (Figure 1).

The images obtained from SEM to check the surface roughness of the samples are presented in Figure 2, 3, and 4.

Discussion

The fracture strength and durability of all-ceramic crowns are influenced by factors such as mechanical nature, manufacturing technique, luting materials, and intraoral conditions. Due to the time-consuming and high cost of clinical studies (in vivo) of all-ceramic crowns, laboratory studies are usually done before that to evaluate the durability of these crowns. In laboratory studies, the parameters are more controllable (38). In laboratory conditions, factors such as design, geometry, size of samples, thickness of luting material, and direction and position of applied force are effective in determining fracture strength (39, 40).

In the present study, to be close and similar to the intraoral conditions, the samples were designed as full-coverage crowns for the upper first premolar teeth, which were made using the CAD/CAM method and Vita MarkII feldspathic blocks. These crowns were cemented by Panavia resin cement to resin dies that were also made by a CAD/CAM machine. The force was introduced by a metal ball with a diameter of 3 mm in the central groove of these covers, which was installed in the space CAD/CAM machine for its placement during the design stages of the cover. In the previous studies, the method of making the samples was different, and in most of them, full coating was not used.

In this study, the force was applied statically to the samples. Other tests, such as flexural strength and cyclic forces, should be investigated in future studies. Also, in this research, a type of feldspathic porcelain vita mark II material was used, which makes it better to use more ceramic materials in the next studies and to make a comparison between different materials. Also, the number of studied samples was small, and the total volume of the sample can be increased. Some believe that glazing increases the strength of dental restorations, possibly due to the reduction of cracks on the surface of the restoration that initiate failure. Polishing also reduces cracks, and laboratory studies have shown that polishing does not reduce physical characteristics (28).

The results showed that the fracture strength of the polished group was significantly higher than the glazed group, which is consistent with the results of some previous studies that stated that glazing does not improve the strength of ceramic materials (44, 43(1), 42, 41). Overglazing has always been mentioned as a process that increases the strength of ceramic restorations, and three reasons have been given for this:

1. Reduction of porosities
2. Reducing the depth of surface cracks
3. Rounding the tips of the cracks

However this issue has not been completely proven, and even several reports in the literature have stated that glazing does not affect the strength of ceramics (45). Polishing in two ways can increase the strength of ceramic materials. One was due to the removal of defects and surface unevenness, and the other was due to the creation of a compressive layer on the ceramic surface. Of course, if the depth of a surface defect is greater than the width of this layer, this layer will lose its strength.

Glazing after lathing probably reduces the strength of the ceramic due to the release of compressive stresses, and this characteristic seems to be more relevant for machinable ceramics that are made by lathing, whereas for handmade restorations, it is different. In other words, ceramics that are not made by hand probably show a different response to overglazing than the usual feldspathic porcelains. For example, Oh et al. concluded in their study that heating for glazing (heat treatment) after pressing in pressable all-ceramic restorations does not affect increasing ceramic strength. (45). Albakry et al. also concluded that in IPS Empress I and IPS Empress II ceramics, the polished group had the highest average flexural strength for both materials and glazing had no significant effect on strength (30).

Another factor that can justify the result of this study is the microstructure of Vita Mark II blocks. These blocks are considered feldspathic ceramics. In feldspathic ceramics, the coefficient of thermal expansion changes after each heating, and during cooling, due to the difference in the coefficient of thermal expansion of matrix glass and crystals, microcracks are created in the ceramics. This means that the crystals shrink more, which causes stress and cracks around the crystals.

In this study, the images taken from SEM showed that the defects and surface roughness of overglazed samples were less than those of polished samples. Studies have stated that stress accumulation is the result of surface roughness caused by different preparations, which has led to different flexural strengths in the studied groups (8). In Jagger et al.'s study, the strength did not increase with overglazing in one of the four types of samples studied, and in the rest of the samples, overglazing significantly increased the strength. The results of this study showed that surface roughness determines the strength of porcelain materials. However, there is an exception, which is about materials whose internal structure leads to the accumulation of stresses that are more important than the stress that causes surface violence. For example, in the case of feldspathic materials, during the glaze and cooling, we have stress accumulation that leads to a decrease in the strength of these materials, which is consistent with the present study. In this study, overglazing increased the strength of the three studied samples, which is probably due to the differences in the type of material, study design, and other study conditions (28).

Conclusion

According to the limitations of this study, the following results were obtained: Using the T-test, the value of the average fracture strength in each group of studied samples was evaluated. The difference between the mean breaking strength values of the two groups of overglazing and polishing was significant. Although the surface of the overglazed samples in the electron microscope image was smoother than the surface of the polished samples, the average fracture strength of the polished samples was higher than that of the overglazed group, and this difference was statistically significant.

Ethics approval and consent to participate

Ethical guidelines have been followed.

Consent for publication

Not applicable.

Availability of data and material

The datasets generated and/or analyzed during the current study are not publicly available since they belong to a hospital database, and their public availability could compromise the confidentiality of participants and other patients registered in the database. However, this data can be made available from the corresponding author on reasonably serious request.

Competing interests

The authors declared that they had no competing interests.

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Authors' contributions

All three authors were involved in the design and formulation of the argument.

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Table 1: Comparison table of averages of two groups of glaze and polishing

	group	N	Mean	Std. Deviation
Fracture load	polish	10	978.10	205.220
	overglaze	10	723.20	139.936

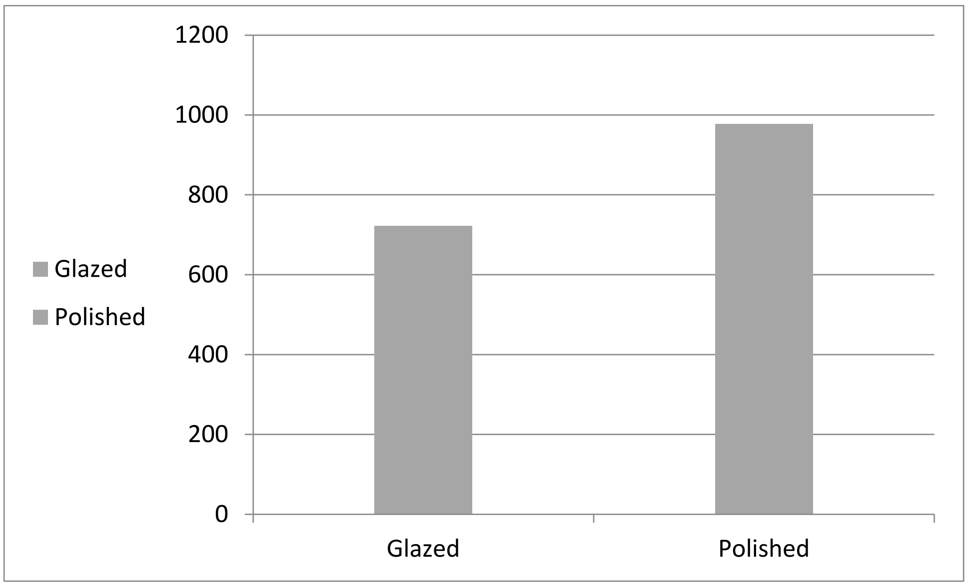

Figure 1: Chart comparing the averages of two groups of glaze and polishing

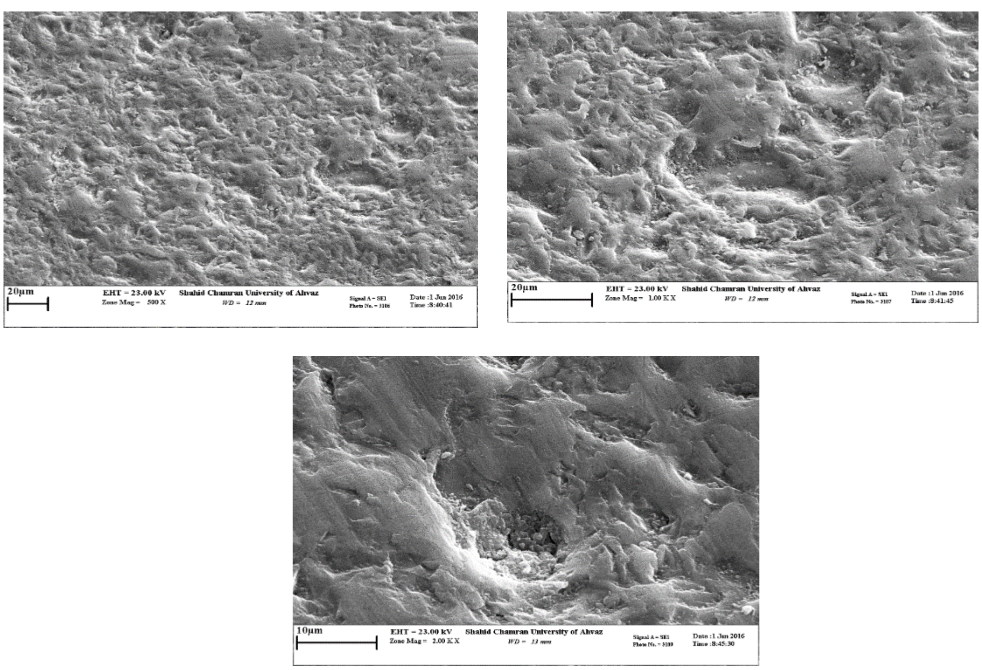

Figure 2: Polished samples in magnifications of 500x, 1000x, 2000x

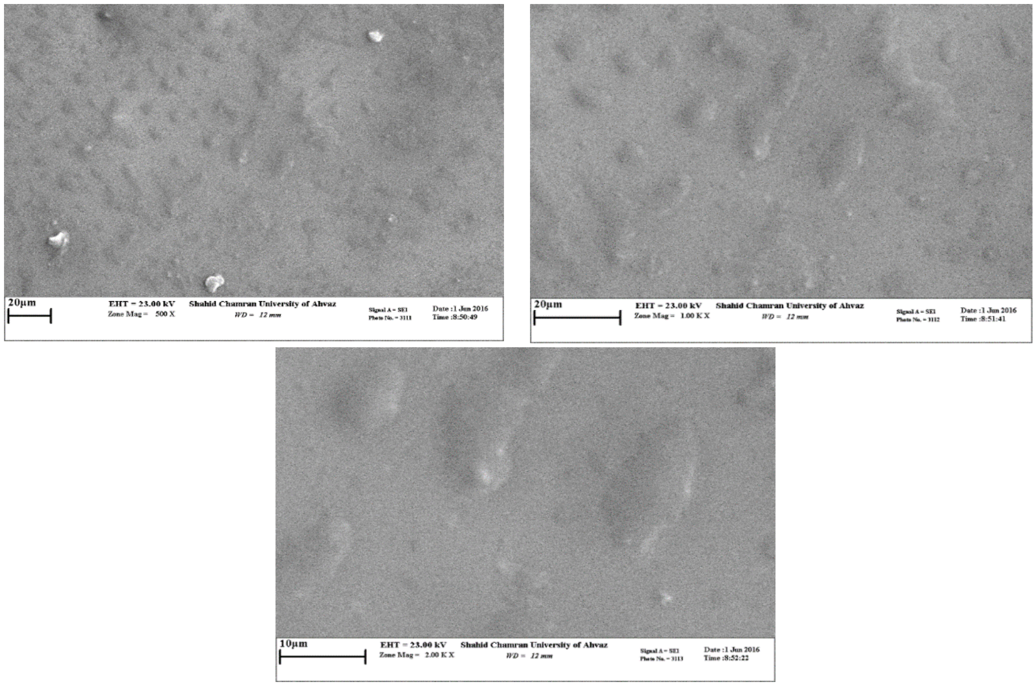

Figure 3-Glazed samples in 500x, 1000x, 2000x magnifications

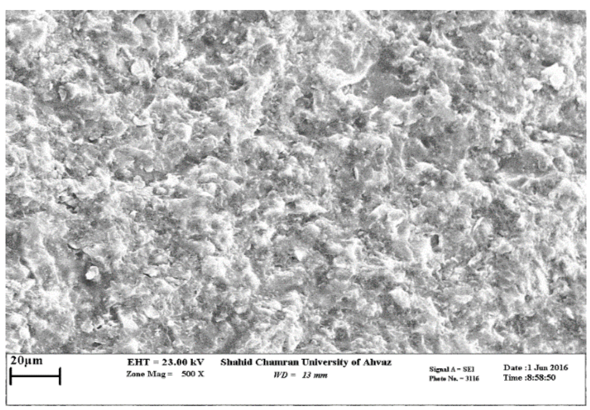

Figure 4: Unprepared samples with magnifications of 500x, 1000x, 2000x