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EFFECT OF DIFFERENT POLISHING SYSTEMS ON SURFACE ROUGHNESS AND COLOR STABILITY OF LITHIUM DISILICATE CERAMICS

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ABSTRACT

Objective: This study aimed to investigate the effect of two polishing systems on the surface roughness and color stability of lithium disilicate ceramic. **Materials and Methods:** Forty disc-shaped lithium disilicate samples were constructed and cemented into a cavity prepared onto the labial surface of freshly extracted bovine teeth; The samples were divided into four groups (10 samples per group); C: Control, SS: Scaling only, SE: Scaling followed by polishing using Eve Diapro lithium disilicate polishers, SD: Scaling followed by polishing using Diatech ShapeGuard ceramic polishing plus kit. The surface roughness was measured before scaling, after scaling and finally after the polishing procedure. The color parameters were measured before and after the staining procedures using VITA Easyshade Advance 4.0 according to the CIE L*a*b* color order system. **Results:** Both polishing systems significantly decreased the surface roughness of the disilicate ceramic and was accompanied by a significant decrease in the color change. However, the color change in the polished group was significantly higher than that of the control glazed group. **Conclusion:** The surface roughness and color stability of lithium disilicate ceramics can be enhanced by recent polishing systems, however, it shows different topography than the glazed ceramic surface.

KEYWORDS: Ceramics, Color stability, Polishing systems, Surface roughness

INTRODUCTION

Over the years, a large array of dental ceramic materials has been introduced into the market as a response to the different demands in mechanical and esthetic properties required for different applications. These materials differ in their mechanical properties as well as chemical composition [(1–3)].

Different ceramic materials exhibit different surface roughness after being glazed or polished which has been documented to affect plaque accumulation, discoloration of the restoration, and esthetics[(4)]. Moreover, in the oral environment, restorations are exposed to many factors that may affect its surface roughness, of these, is the scaling procedure that is generally recommended for the periodic control of plaque accumulation and calculus growth and may be prescribed every 3-4 months for patients with periodontal disease[(5,6)]. Scaling is mainly conducted with either an ultrasonic scaler or a manual periodontal curette. The use of an ultrasonic scaler may induce increased roughness of the restoration which may reduce the efficiency of mechanical cleaning processes and enhance the initial adhesion of bacteria and their subsequent colonization to form a biofilm and plaque,[(7)] gingival irritation, and recurrent caries[(8)], causing the adherence of agents responsible for changing the color. Therefore, careful intraoral

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finishing and polishing of the ceramic surfaces after scaling using the proper technique and materials are recommended [4,9].

For this purpose, a variety of ceramic polishing systems are available in the market. These systems are usually composed of a variety of materials such as fluted carbide burs, rubber wheels, rag wheels, mounted points, abrasive stones, sandpaper discs, and diamond paste [10]. Although polished ceramic has been reported to have similar surface roughness to glazed ceramic,[11–13] it has been reported that surface roughness differs depending on the polishing system, rotation speed of the device, pressure, duration, and type of ceramic to be polished[14].

Reviewing the literature, there were studies on the effects of scaling on different restorative materials and the surface alterations induced in relation to scaling methods,[9,15] however, few studies have been reported about the surface changes by repeated ultrasonic scaling and subsequent intraoral polishing. Therefore, the aim of this study was to evaluate the surface roughness changes of lithium disilicate ceramics after ultrasonic scaling and polishing with two different intraoral polishing systems.

MATERIALS AND METHODS:

A total of fourty bovine anterior teeth were collected and cleaned of all attached soft tissue, then were decapitated 2 mm below the cemento-enamel junction. The labial surfaces of the teeth were flattened using a cylinder diamond stone to obtain a flat area of 1x1 cm^2. The teeth were mounted in acrylic blocks, then a circular cavity of 5 mm diameter and 0.5 mm depth was prepared using wheel diamond (Komet Dental, Gebr. Brasseler) stone on the flat surface.

Fourty disc shaped lithium disilicate (IPs e.max Press, Ivoclar Vivadent, Inc) samples of 0.5 mm thickness and 5 mm diameter corresponding to the prepared cavities were constructed according to the manufacturer's instructions. The fitting surfaces of the ceramic discs were etched using hydrofluoric acid (9.5 %) (BISCO, Inc, America) porcelain etchant followed by porcelain primer (Pre-Hydrolyzed Silane Primer) (BISCO, Inc, America) application according to the manufacturer's instructions. The cavities on the teeth surfaces were acid-etched using phosphoric acid (37 %) (Eco-Etch, Ivoclar Vivadent) followed by the bonding agent (TE-Econom Bond, Ivoclar Vivadent) according to the manufacturer's instructions. Finally, the discs were cemented into the cavities using Variolink N clear resin cement (Ivoclar Vivadent, Inc).

The samples were divided into four groups (10 samples per group); **C:** Control, **SS:** Scaling only, **SE:** Scaling followed by polishing using Eve Diapro lithium disilicate polishers, EVE Ernst Vetter GmbH (Diamond impregnated 2 stages polishing system), **SD:** Scaling followed by polishing using Diatech ShapeGuard ceramic polishing plus kit, COLTENE Group (Diamond impregnated 3 step silicone polishers).

After that, scaling and polishing procedure was performed on all samples using a specially designed and fabricated apparatus to standardize the procedure. The samples were mounted onto one side of the double-pane balance and attached in place using screws. Scaling procedure was conducted using an ultrasonic scaler handpiece (Satalec, Acteon, North America) at intermediate power setting (level 5 of 14 grades). The ultrasonic scaling tips were angled 90° relative to the surface of sample. A constant force of 30 gm was applied to the ultrasonic scalar tip by the vertical movement of a counterweighed balance. A standardized 5 mm horizontal movement and three consecutive cycles of 20 seconds each of the ultrasonic handpiece at a speed of 2 Hz was achieved and operated by the control box. The polishing procedure was performed according to manufacturer instructions. Polishing was performed for each instrument in one direction for 30 seconds by using low-speed handpiece[16,17]. After polishing procedures, the specimens were rinsed with air-water spray for 15 seconds and then ultrasonically cleaned for 1 minute in 100% distilled water and then air dried.

The surface roughness of samples was measured before and after polishing using the profilometer; Surface Roughness Tester TIME3202 (TR220) (Landmark Industrial Inc, USA), at cut off 0.25mm, number of cuts 1 and range ±40 µm. Measurements were made at three different regions were evaluated in each sample to determine the surface roughness (Ra) values and averaged to determine the mean values. Then the ceramic surface was analyzed using atomic force microscopy using AutoProbe CP-Research (Thermomicroscope, Bruker Nano Inc., USA) operated in contact mode using nonconductive silicon nitride probe, at scan area of 25 µm, scan rate of 1 Hz and number of data points 256x256 m^2 was using proscan 1.8 software for controlling the scan parameters and IP 2.1 software for image analysis.

Staining procedure:

Staining procedure was conducted using coffee solution (Nescafé Classic; Nestlé Egypt). The coffee solution was prepared according to the manufacturer's instructions by using 3.6 g of coffee and 300 mL of hot water. The solution was stirred for 10 minutes and passed through filter paper (Melitta; Melitta Haushaltsprodukte GmbH & Co Kg). In the interval between the 2 color measurements, all specimens were stored in coffee solution in an incubator (Model B 28, BINDER GmbH) at 37°C for 12 days, which is equivalent to 1 year of coffee consumption [18]. The solution was stirred every 12 ± 1 hour. After 12 days, the specimens were washed with tap water and dried with tissue paper.

The color parameters of each specimen were measured before and after the scaling and staining procedures using VITA Easyshade Advance 4.01 (VITA shade, VITA made, VITA) according to the CIE L*a*b* color order system.

Data was analyzed using Statistical Package for Special Science (SPSS)® (IBM SPSS Statistics 26). Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess data normality. All data showed normal (parametric) distribution. Data were described as mean ± standard deviation (SD). One-Way ANOVA followed by Tukey's post-hoc test was used for comparison of change in color and final total roughness between all groups. T-test was used to compare the change in surface roughness using different polishing kits. Correlation between continuous variables was performed using pearson's correlation coefficient. The significance level was set at $P \le 0.05$.

RESULTS

Mean values of total surface roughness after polishing were statistically significantly different among groups, ($P< 0.001$). Both polishing kits (SE= 0.277, SD= 0.342) were statistically significant different from that of the group subjected to scaling without polishing (SS = 0.5388) $P<0.001$, while there was no statistically significant difference between the two polishing groups, however. Only the mean Ra values of the SE group was not statistically significantly different from that of the control group (C= 0.236), (Figure 1). As for the mean change in surface roughness of the two polishing kits (ΔRa), there was no statistically significant difference in ΔRa of both groups, (Figure 2).

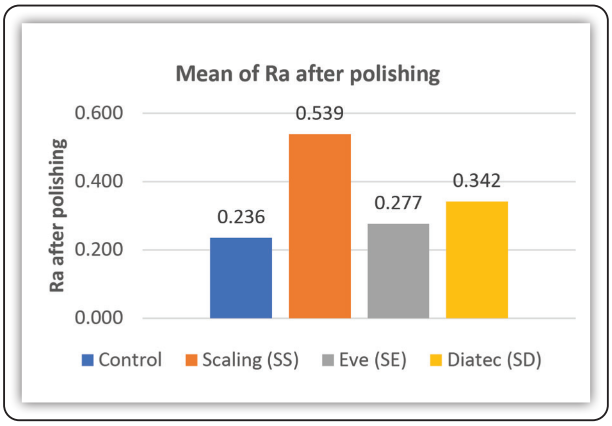

FIG (1) Bar chart representing mean values of Ra after polishing

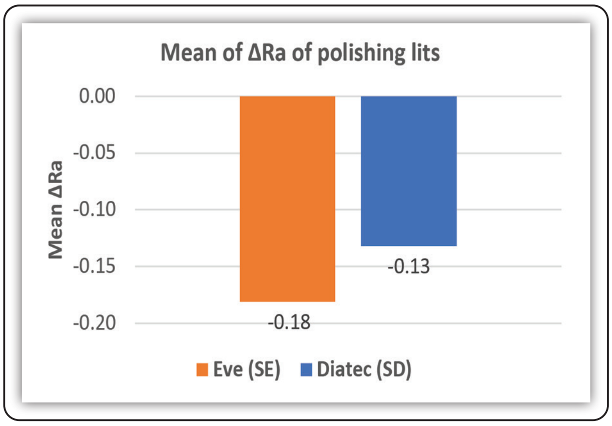

FIG (2) Bar chart representing mean values ΔRa of polishing kits

The atomic force microscopy (AFM) revealed that ultrasonic scaling resulted in scraping of the ceramic surfaces and loss of their original texture, leading to increased surface roughness. The polished groups showed a smooth appearance with a small number of irregular, scattered pores and scratches, (Figure 3).

For the color change of different groups, there was statistically significant difference among all groups with the SS group showing the statistically significant highest mean value of color change (ΔE= 12.21), followed by group SD (ΔE= 7.22) then the group SE (ΔE= 4.8) and finally the control group (ΔE= 2.75) showing the statistically significant lowest mean value of ΔE, (Figure 4).

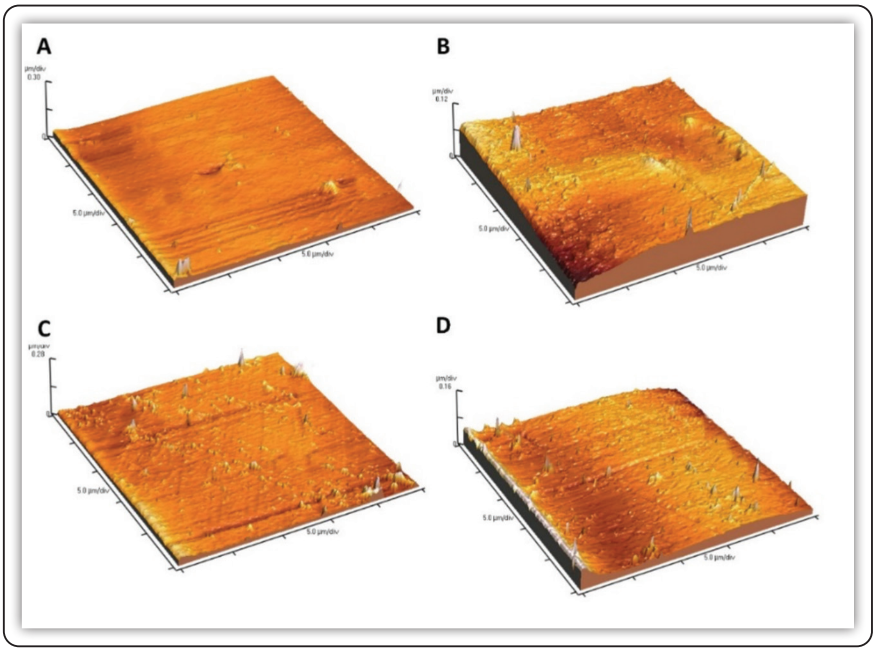

FIG (3) AFM

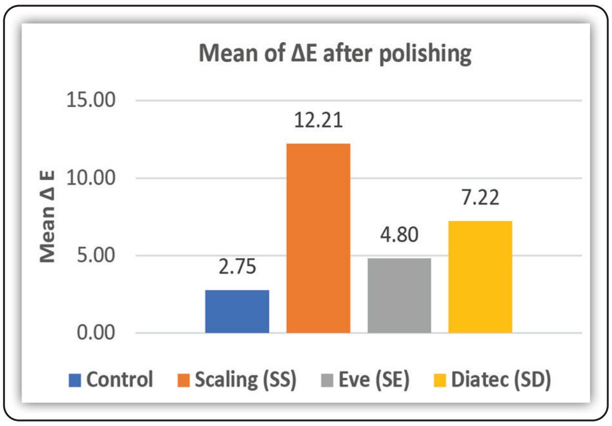

FIG (4) Bar chart representing mean values of ΔE after polishing

The results showed a statistically significant positive (direct) correlation between surface roughness and color change r=0.79, (P<0.001).

DISCUSSION

It is essential to establish surface conditions favorable to oral hygiene maintenance considering the characteristics of restorative materials. According to previous studies, the surface of lithium disilicate ceramics can be increasingly roughened by the scaling procedures which adversely affects the color stability of the ceramic [19,20]. Thus, it is important to smoothen the rough surfaces of restorative materials from ultrasonic scaling by using an intraoral polishing system. In fact, intraoral polishing of ceramic restorative material is reported to be difficult due to its high hardness [9,12].

This study evaluated the in-vitro effect of ultrasonic scaling and subsequent intraoral polishing using two different ceramic polishing kits on the surface roughness and color stability of lithium disilicate ceramic.

According to the results of this study, the two polishing systems used showed effective decrease in the surface roughness of the lithium disilicate ceramic after the scaling procedure and subsequently less color changes. However, the characteristics of the polished surface observed by AFM were different from that of the glazed surface which showed pores and scratches. The presence of pores in the ceramic material as a result of the manufacturing technique is inevitable and will open up due to ultrasonic scaling procedure resulting in a rough surface. This finding is in agreement with previous reports investigating the effects of different polishing systems on the surface roughness of ceramics [21–23].

Color change (ΔE) mathematically indicates the difference between the Commission Internationale de l'Eclairage (CIE) L*a*b* coordinates of different samples or the same sample at different occurrences [24,25]. The human eye has a limited ability to perceive color differences. It cannot perceive color change values less than 1 [24,26,27]. Color change values between 1 and 3.3 indicate a perceptible and clinically acceptable range, while color change values of 3.3 and higher are indicated as unacceptable under clinical conditions [28]. A color change value of 3.3 has been used as the upper limit in several studies regarding the perceptibility of color differences [29–31]. Although, the polishing systems used in the present study revealed decrease in total surface roughness and amount of color change of the samples, the color change was more than the clinically accepted values which may indicate an overall change in surface characteristics after scaling and polishing, this was evident in the results of the atomic force microscopy showing pores and scratches that were not identified on the glazed surface of the control group. These pores may be caused by the removal of the lithium disilicate crystals during the polishing procedure.

CONCLUSIONS

Within the limitations of this study, the following conclusions can be drawn:

- The surface roughness of lithium disilicate ceramic significantly increased after repeated scaling.
- Polishing of lithium disilicate ceramic can be effective in decreasing the final surface roughness.
- Color stability of the lithium disilicate ceramic can be affected by the removal of the glazed surface

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