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Original Article

Effect of polishing methods on the surface roughness of different temporary restorative materials

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Abstract

Aim: The purpose of this study was to evaluate the effects of different polishing methods on the surface roughness of temporary prosthetic restorations.

Methodology: In this study, 200 specimens were obtained from Structur 2, Imident, FSM Duo CAD, and Han Temp Crown. All specimens were sanded with 400-, 800-, and 1000-grit silicon carbide. Next, the specimens were divided into five subgroups (n = 10). The specimens in first group were sanded with 1200-, 1600-, and 2000-grit silicon carbide sandpaper. The second group was polished with an aluminum oxide-containing disc. The third group was polished with a diamond-containing pad. A glaze bond was applied to the specimens in the fourth group. The fifth group was glazed with a coat of nano-filled resin. Then, the surface roughness of all specimens was measured with a profilometer. A two-way ANOVA test was performed using SPSS 20.0. Finally, the microstructures of the surfaces were examined by a scanning electron microscope at 5000× magnification.

Results: Statistically significant results were obtained between the temporary materials and polishing methods in terms of surface roughness ($p < 0.05$). For the polishing method, the highest surface roughness values were observed in the control group (0.50 ± 0.15). The lowest surface roughness values were observed in the Equia Forte GC coat group (0.25 ± 0.10). Among the temporary crown materials, the highest roughness was observed in Imicryl specimens. (0.45 ± 0.17), while the least roughness was the polymethyl-methacrylate (PMMA) specimens (0.17 ± 0.10).

Conclusion: Surface polishing and finishing procedures might positively affect the surface roughness of temporary materials. Furthermore, materials made via computer-aided design and computer-aided manufacturing (CAD-CAM) demonstrate structural advantages and may be preferable.

Keywords: Dental polishing, surface roughness, temporary crown material, temporary dental restoration, CAD-CAM

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Introduction

Using temporary crowns is crucial for protecting prepared teeth during the production stage of fixed dentures and providing comfort until the end of a patient's treatment (1). Temporary restorations should be strong enough to resist chewing forces during their use, stabilize the tooth, protect the pulp and periodontium, and have good edge matching and aesthetics. Temporary restorative materials have a relatively lower fracture resistance compared to permanent restorative materials, yet an acceptable temporary restoration should not be much different from a permanent restoration (1, 2). Thus, when a temporary bridge with a long body is manufactured, for example, more robust temporary restoration materials should be used, especially for those with temporomandibular joint disorders in which occlusal vertical size should be changed, as well as in patients with bruxism and overloaded areas (3-5).

Materials with different chemical structures are used for temporary restoration. Polyethyl-methacrylate (PEMA), polymethyl-methacrylate (PMMA), bis-acryl-based resins, and micro filler-containing resins are among the materials commonly used in clinics (5). It is possible to make more robust temporary restorations today through computer-aided design/computer-aided manufacturing (CAD/CAM) techniques. Also, restorations made with CAD/CAM restorations shorten the time spent in the dental chair and present superior aesthetics and mechanical characteristics (2, 6).

An oral environment can be very abrasive to dental materials. An individual's diet (depending on its content) and saliva may react with restoration materials, damage their structure, and affect their physical and mechanical characteristics (7). The roughness of hard oral tissues plays a significant role in the adhesion and retention of oral microorganisms. In particular, supragingival surface roughness increases plaque formation (8). Increasing the accumulation of plaque on rough restoration surfaces also causes inflammation in periodontal tissues. Therefore, inadequate polishing causes rough surface formation and, thus, more plaque accumulation and periodontal tissue inflammation (8, 9).

Many finishing and polishing systems are available on the market for use in resin-based restorations (10, 11). Moreover, every newly developed system aims to make clinical application easier by decreasing the operation stages (12). Thus, single-stage systems were developed that use, for example, silicon carbide brushes with added abrasive rubber-containing micro diamond particles (13). Although many studies have been conducted to evaluate and compare the efficiency of finishing and polishing systems, a consensus regarding which is best has not yet been reached (14).

Therefore, the aim of this study was to evaluate the effect of polishing methods on the surface roughness of various temporary restoration materials. The null hypothesis predicted no difference in the effect of polishing methods on the surface roughness of different temporary materials.

Materials and Methods

A total of 200 specimens, including 10 from each specimen group, were acquired. All specimens were wet sanded using 400-, 800-, and 1000-grit SiC paper (Metkon Gripo 2V, Bursa, Turkey) and polished. Tables 1 and 2 display the temporary crown materials and polishing products used in the study. Specimens acquired from CAD/CAM blocks were cut using a water-cooled cutting device (Isomet 4000, Buehler, IL, USA). Structur 2, Imident, and Han Temp Crown specimens were prepared using silicon impressions 10 mm in diameter. Smooth surfaces were acquired by covering the non-polymerized resin with a glass and pressure was applied during polymerization. Revotek LC was polymerized for 40 seconds with a halogen light source (GC D-Light Pro, GC Dental Products Europe, Belgium). The Imident specimens were polymerized in a production flask using the heat-polymerization method.

Table 1. Temporary crown materials used in the study

Product Name	Material Type	Manufacturer	Lot number
FSM Duo CAD	PMMA	FSM Dental, Ankara, Turkey	21923
Imident	Self-adhesive acrylic resin	Imicryl, Konya, Turkey	19322
Structur 2	Bis-acryl resin	Voco, Cuxhaven, Germany	1840501
Han Temp Crown	Type 1 Resin	HDC Dental, Bucharest, Romania	TC571905

PMMA: polymethyl methacrylate.

Table 2. Polishing materials used in the study

Product Name	Material Type	Manufacturer	Lot number
Sof-Lex Polishing Kit	Aluminum oxide abrasive discs	3M Espe, St. Paul, MN, USA	N632911
EQUIA Forte Coat Unit Dose	Self-adhesive acrylic resin coat	GC, Tokyo, Japan,	1501151
Diapolisher Paste	Diamond polishing paste	GC, Tokyo, Japan,	1904021
Luxatemp-Glaze & Bond	Light curing surface-sealing material	DMG, Hamburg, Germany	806842

The specimens in the control group were wet sanded with 1200-, 1600-, and 2000-grit silicon carbide sandpapers (Metkon Gripo 2V, Bursa, Turkey) for 10 seconds each.

Mechanic Polishing Group SL: Polishing discs with different grains (3M Soft-Lex, 3M Espe, Seefeld, Germany) were applied to specimens polished with aluminum oxide-containing polishing discs. Following the manufacturer's directions, the orange-colored discs were applied using an electric micromotor (KaVo Dental GmbH, Biberach/Riss, Germany) at a constant speed of 10,000 rpm for 15 seconds, starting with the specimens with thick grains and ending with the ones with thin grains.

Dia Polisher Group (DP): In the group polished with a diamond filler pad (Dia Polisher, GC Dental Products Europe, Leuven, Belgium), the pad was applied to each specimen using a felt brush installed on an electric micromotor at a speed of 10000 rpm.

Luxatemp Group (LT): Following the sanding operation, a glaze bond (Luxatemp, DMG, Hamburg, Germany) was applied to the polished specimens with an applicator brush for five seconds, according to the manufacturer's suggestions. The specimens were then lightly cured with a halogen light source for 10 seconds.

Equia Forte GC Group (EF): Following the sanding operation, a nano-filler resin coat (Equia Forte GC, Japan) was applied to the polished specimens with an applicator brush for five seconds, according to the manufacturer's suggestions. The coat was lightly cured for 20 seconds using a light-emitting diode curing unit (Hilux Optimax, 800 mW/cm^2, Benlioglu Dental, Ankara, Turkey).

The average surface roughness (Ra) of all specimens was measured with a profilometer (Mitutoyo SJ 301, Mitutoyo, Kawasaki, Japan) after the surface operations were completed. The measurement length of the specimens was adjusted to 5.6 mm. To determine the surface roughness of each specimen, measurements were performed on three different dimensions of the specimens' surfaces by rotating each specimen 120° after every measurement. The averages of the acquired Ra values were then taken. The microstructures of the surfaces were examined with a scanning electron microscope (SEM; Evo LS10, Zeiss, Germany) at 5000x magnification.

Statistical analysis

The analyses were performed using SPSS 23.0 (IBM SPSS Inc., Armonk, NY, USA), and $p < 0.05$ was considered statistically significant. A two-way ANOVA test was used to analyze the study's data. The Bonferroni test was used for multi-comparisons. The selected level of statistical significance level was $p < 0.05$.

Results

The results of the two-way ANOVA test are provided in Table 3. The primary effect of the different material groups was found to be significant to the Ra values ($p < 0.001$). The mean surface roughness values were 0.17 in the PMMA specimens, 0.45 in the Imicryl specimens, 0.44 in the Structur 2 specimens, and 0.34 in the Han Temp specimens. The effect of the polishing methods on the Ra values was significant ($p < 0.001$). The mean surface roughness values were 0.50 in the control group, 0.45 in the SF group, 0.27 in the LT group, 0.29 in the DP group, and 0.25 in the EF group. The interactions between the materials and polishing methods had a significant effect on the Ra values ($p < 0.001$). The factor that most affected surface roughness was the material groups ($\eta^2 = 0.647$). At least 76.2% of the Ra values could be explained by the materials and polishing methods ($\eta^2 = 0.762$).

Table 4 shows the mean values, standard deviations, and multiple comparisons between the groups. In the pairwise multi-comparison test among the material groups, PMMA had a statistically significantly lower Ra value than the other groups. A statistically significant difference was found between Imident and Han Temp, and Imident had a higher Ra value than Han Temp. A statistically significant difference was found between Structur 2 and Han Temp, and Han Temp had a lower Ra value than Structur 2. No statistically significant difference was found between Structur 2 and Imicryl. In the pairwise comparison among the polishing groups, no significant difference was found between the control group and the SF group.

Table 3. Two-Way ANOVA results

Source	Mean Square	F	Sig.	Partial Eta Squared
Groups	.850	109.771	<001	.647
Techniques	.528	68.215	<001	.603
Groups * Techniques	.035	4.492	<001	.230

R^2=0,762

Table 4. Descriptive statistics and comparisons of material and polishing methods

Groups	Control (Mean±SD)	Equa Forte GC Coat (Mean±SD)	Dia Polisher (Mean±SD)	Luxatemp (Mean±SD)	Mechanic polishing (Mean±SD)
Imicryl	0.609±0.06[Aa]	0.285±0.04[Ab]	0.418±0.13[Ab]	0.318±0.09[Ab]	0.595±0.06[Aa]
Han Temp	0.438±0.14[Ba]	0.237±0.07[Bb]	0.272±0.09[Bb]	0.241±0.09[Bb]	0.419±0.08[Ba]
Structur 2	0.550±0.12[Ba]	0.301±0.09[Bb]	0.261±0.07[Bb]	0.374±0.1[Bb]	0.593±0.13[Ba]
FSM Duo CAD	0.258±0.09[Ca]	0.093±0.02[Cb]	0.097±0.03[Cb]	0.093±0.04[Cb]	0.188±0.06[Ca]

SD: Standard deviation

The same letter indicates that roughness values were not significantly different materials ($p > 0.05$)

There was a statistically significant difference between the control group and the EF, DP, and LT groups. The control group had higher Ra values than the other polishing groups. The mechanic polishing group had a significantly higher Ra value than the EF, DP, and LT groups. No statistically significant difference was found between the EF, DP, and LT groups. On the other hand, the EF group had the lowest Ra value, followed by the LT and DP groups. Figure 1 shows the graphic for surface roughness according to the polishing methods and temporary materials.

The SEM results clearly demonstrated the influenced surface morphology created by the tested polishing and finishing procedures when compared to the baseline. Figures 2–6 show the representative SEM images of the specimens' baseline surfaces with the tested materials and polishing groups.

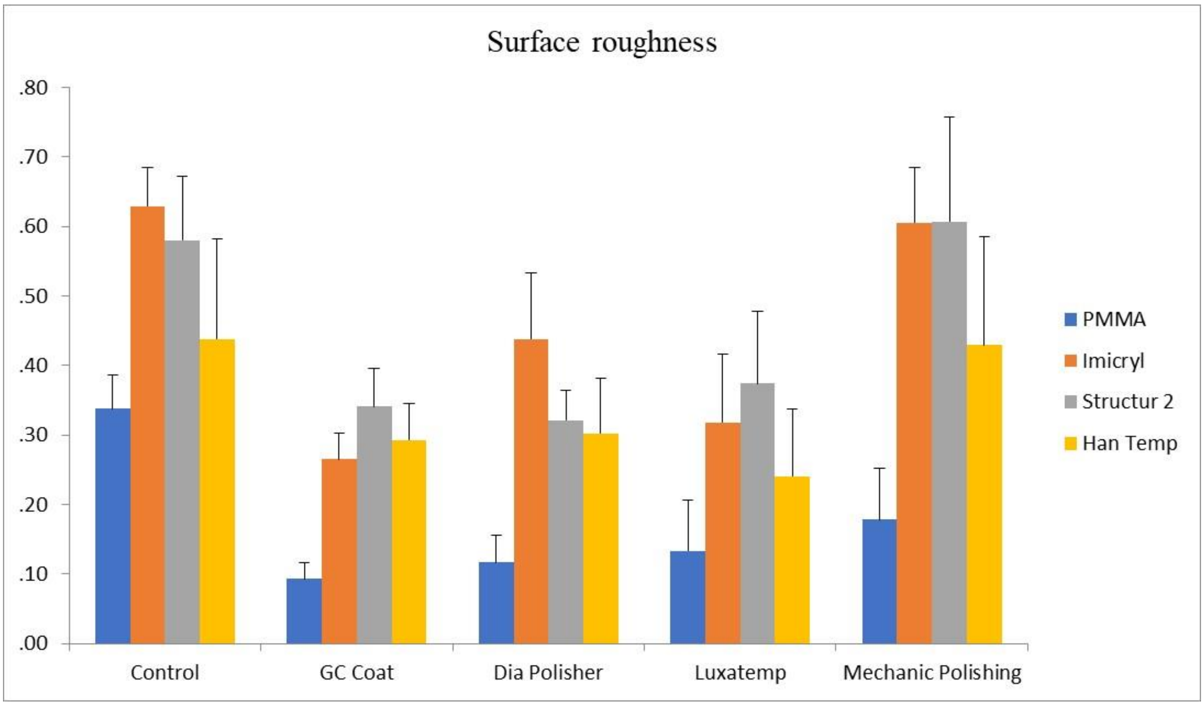

Figure 1. Graph of the surface roughness observed after using the polishing methods of the different experimental groups.

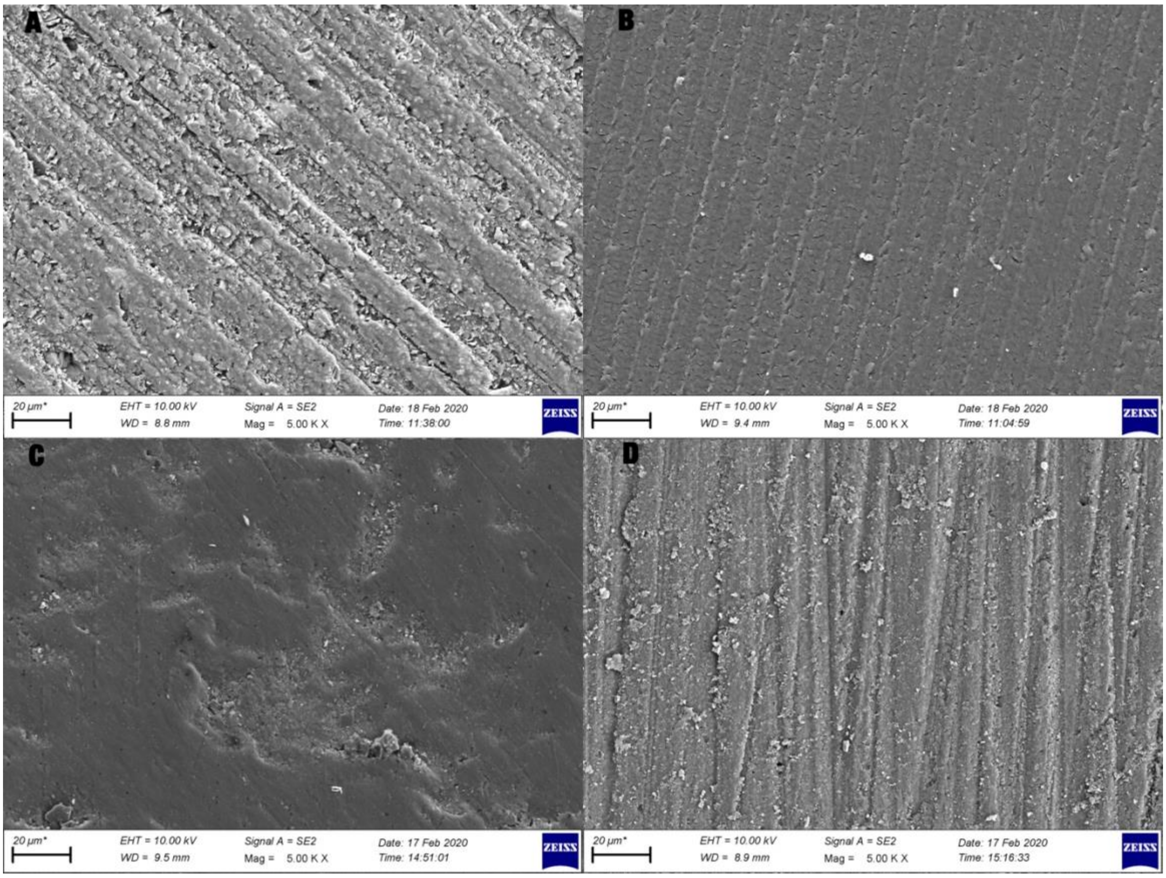

Figure 2. SEM images of the control group. (A) Han Temp, (B) PMMA block, (C) Imident, (D) Structur 2.

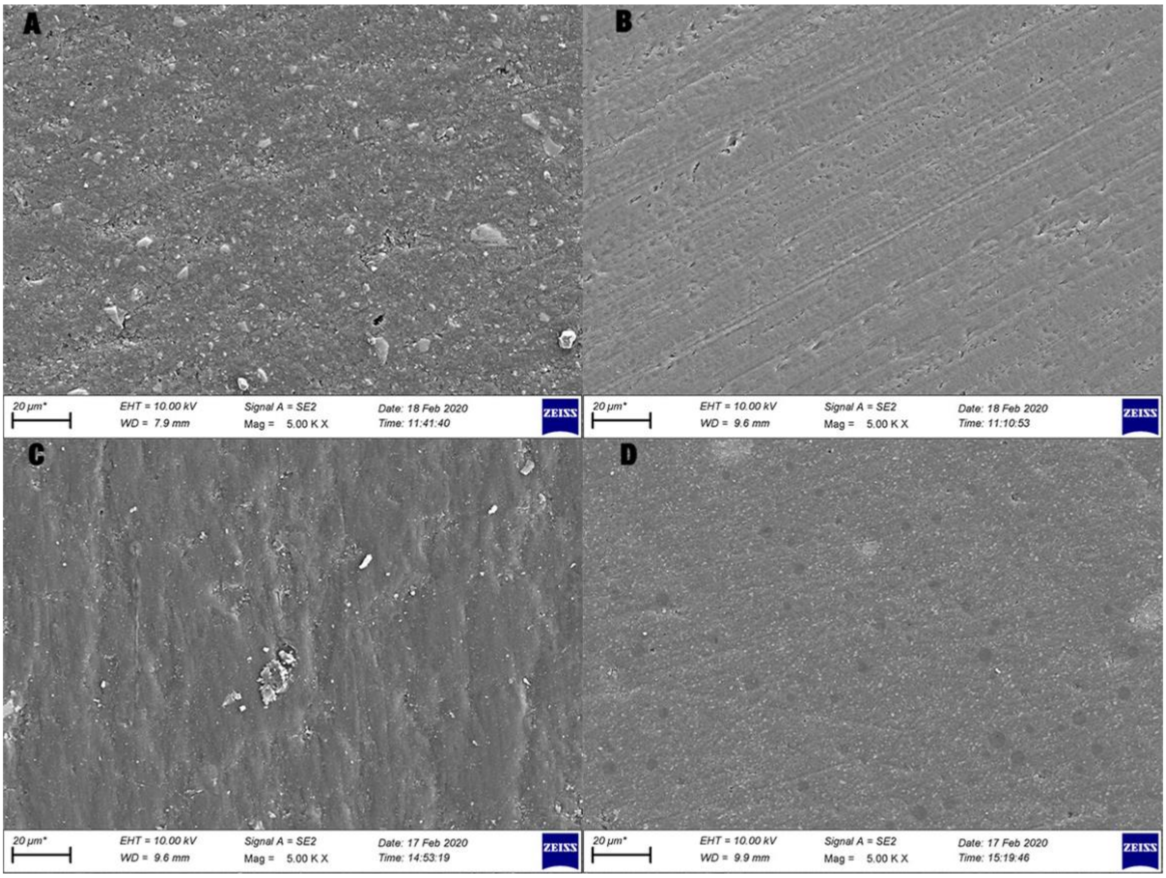

Figure 3. SEM images of the mechanical polishing group. (A) Han Temp, (B) PMMA block, (C) Imident, (D) Structur 2.

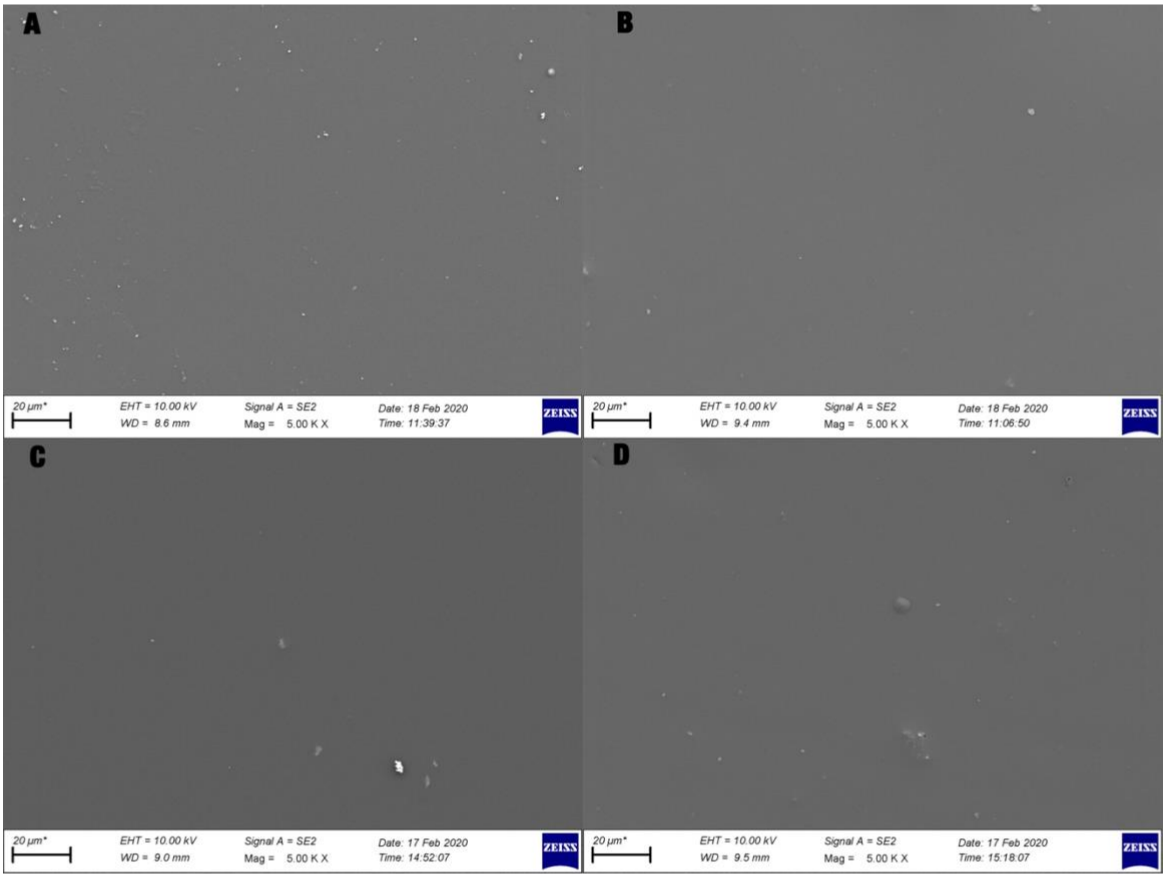

Figure 4. SEM images of Luxatemp group. (A) Han Temp, (B) PMMA block, (C) Imident, (D) Structur 2.

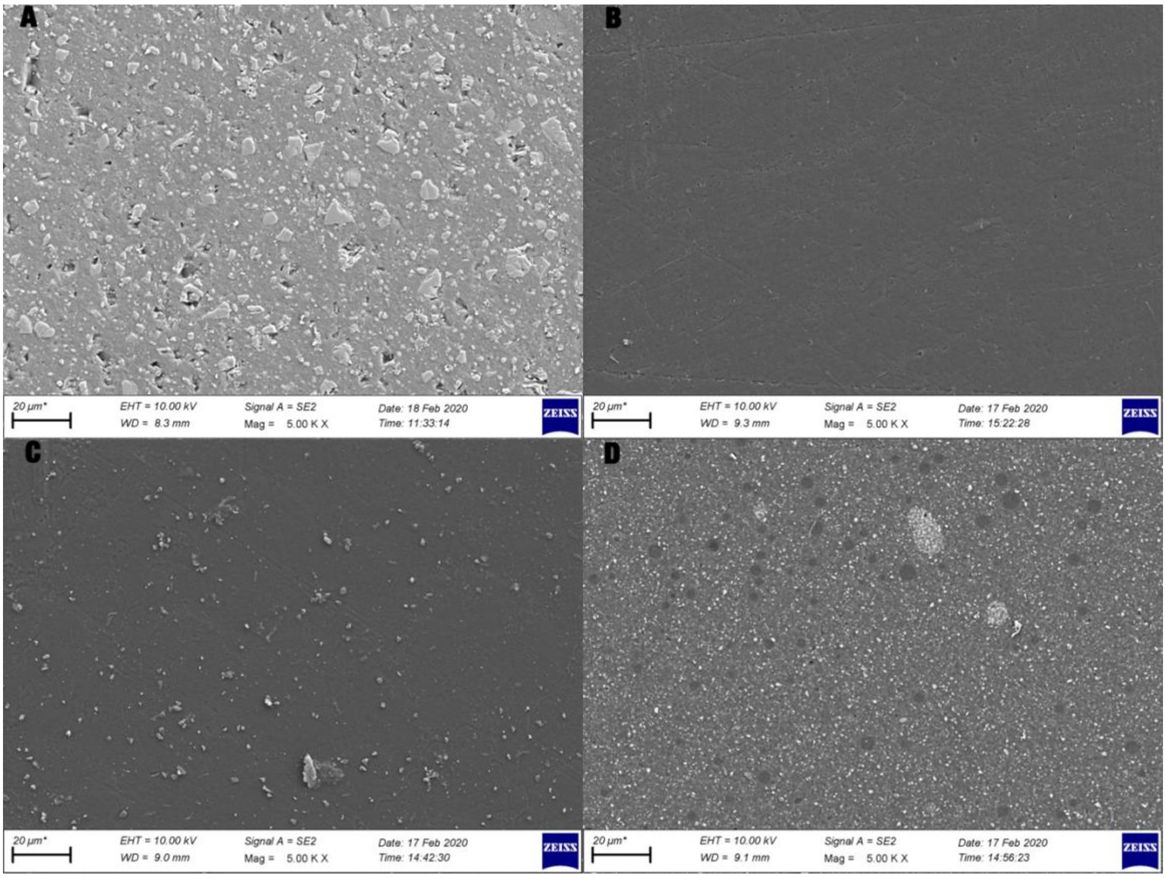

Figure 5. SEM images of Dia Polisher group. (A) Han Temp, (B) PMMA block, (C) Imident, (D) Structur 2.

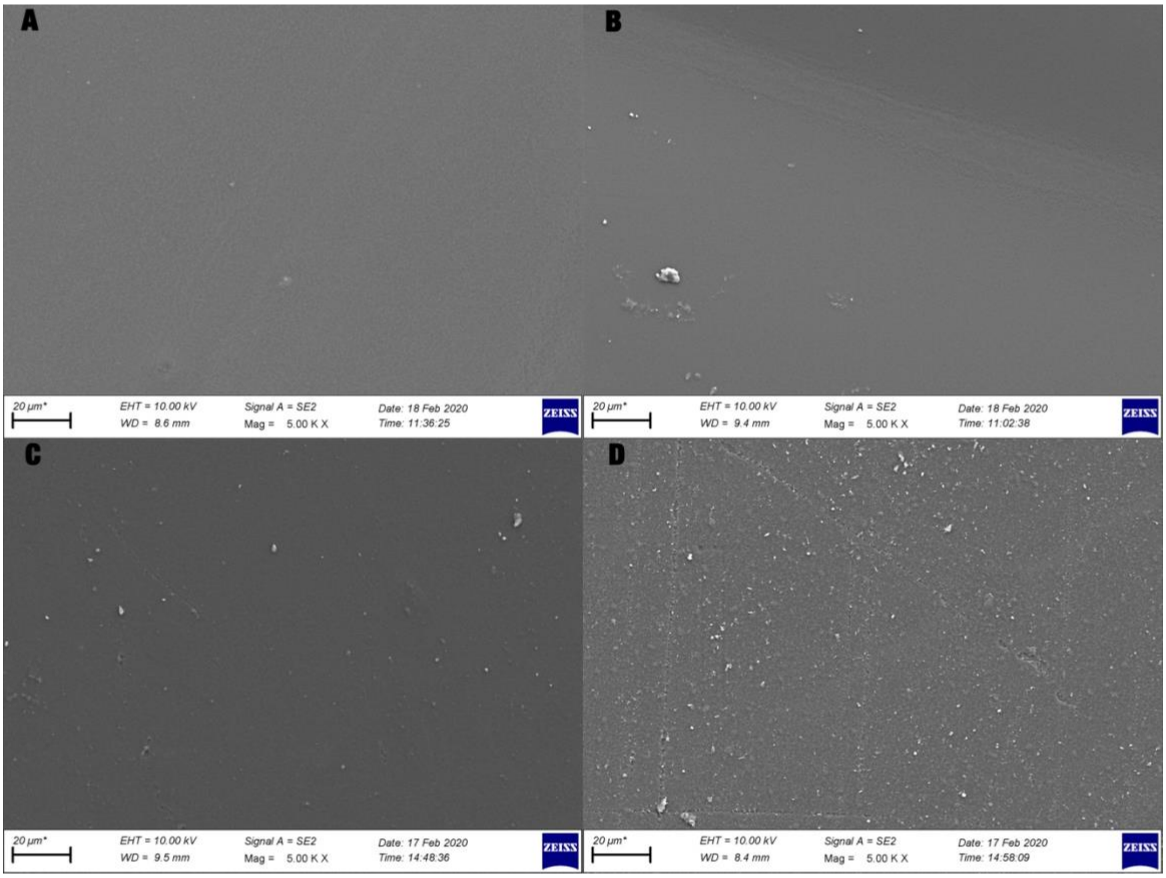

Figure 6. SEM images of Equa Forte GC Coat group. (A) Han Temp, (B) PMMA block, (C) Imident, (D) Structur 2.

Discussion

This study examined the effect of different polishing operations on surface roughness by applying them to four different temporary crown materials. Statistically significant values were found among the groups. Furthermore, the null hypothesis was rejected.

Temporary crowns and bridges are produced to protect teeth and supporting tissues until a permanent restoration is prepared (15). Temporary restorations used in permanent prosthetic treatment should be able to facilitate certain goals, such as aesthetics, comfort, speech, function, periodontal health, and permanent restoration rehearsal (16). The materials and techniques used in temporary restoration manufacturing must have specific qualities to meet the requirements of the planned treatment (17). Mechanical and physical characteristics, ease of use, and biocompatibility influence the material selection for temporary restorations (18). The aesthetic success of temporary restorations is directly related to surface roughness and gloss (19). In addition to causing problems related to aesthetics, surface roughness also shortens the clinical life of the restoration due to plaque retention, surface coloring, and secondary decay formation (20). Factors influencing the surface roughness of resin restorations include the monomer type they contain, the shape and size of the fillings, and the polymerization depth (21).

In composite resin materials, surface roughness is related to the size, rigidity, and amount of filling particles. In temporary restoration materials, the presence of filling particles in the structure or the chemical characteristics of the materials can affect their polish ability and resistance to coloring. Other factors affecting roughness can include the abrasive particles used in the polishing method, the pressure applied to the surface that will be polished, the polishing time, and the abrasion direction.

Moreover, the finishing and polishing system plays as much of a role as the material structure and content in the acquisition of smooth surfaces in composite resins. Finishing is the shaping operation performed to acquire an ideal anatomic form, and polishing is the operation of decreasing roughness and removing irregularities that have formed on the surface during the finishing operation (22). Carbide and diamond drills, aluminum oxide particle-containing abrasive disks, sand papers, and polishing pastes are used for the finishing and polishing operations of aesthetic restorations. Some studies have shown that highly smooth surfaces can be acquired with multi-stage flexible disks containing aluminum oxide particles (23). Tupinamba et al. analyzed the surface roughness of temporary restoration materials when using polishing methods. In that study, the lowest surface roughness was found in the groups where a goat brush and diamond polishing paste were applied. The materials with the lowest roughness in the study included Structur 2 and Protemp 4 (24).

Studies have shown that polyethyl-methacrylates have less wear resistance and fewer aesthetic characteristics than polymethyl methacrylate and bis-acryl resins and that the superficial layer of polymerized resin isn't completely polymerized when it contacts oxygen. More rigid, robust, and aesthetic surfaces can be acquired by leveling and polishing to remove the surface layer (25). Although some of the specimens we acquired for our study had smooth glass surfaces, all specimens were leveled and polished by wet sanding with 400 grit, 800 grit, and 1000 grit SiC sandpaper in order to remove any surface layer that would cause roughness. Şen et al. compared the surface roughness of six different temporary restoration materials, including three bis-acryl resins and three methacrylate resins (26). Using Iso-Temp, Protemp 2, Structur 2, Dentalon Plus, Kerr TAB 2000, and Temdent materials, they polished the specimens with aluminum oxide paste and diamond paste. Profilometric analysis showed that both polishing methods resulted in bis-acryl groups that had a higher surface roughness than that of methacrylate-based resin groups. Şen et al. concluded that methacrylate materials could be more effectively polished. Low Ra values were recorded for PMMA material in our own study as well (26).

In our study, we used disc-shaped specimens with smooth surfaces to evaluate surface roughness. But the temporary restoration used in the mouth has the form of a tooth and has several indents. Because of the irregular surface structure, effective polishing is not possible on all surfaces. Among the limitations of this study, then, is the fact that our findings cannot be directly applied clinically given the shapes of the specimens we worked with.

Conclusions

All of the polishing methods that we studied reduce the roughness of temporary crown materials. Since PMMA CAD/CAM temporary crown material is produced industrially, it has a highly homogeneous structure. Since the material does not have porous content, it is easy to obtain a smoother surface by polishing.

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