BALKAN JOURNAL OF STOMATOLOGY ISSN 1107 - 1141

Effect of Prophylaxis Pastes on Surface Roughness of Direct and Indirect Restorative Materials

SUMMARY

Objectives: *The purpose of this study was to evaluate the effect of 2 prophylaxis pastes on surface roughness of composites cured with halogen or additionally post-cured, and to compare it with porcelain.*

Materials and Methods*: 42 specimens with 2 mm in thickness and 8 mm in diameter from the composites Miris (M; Coltene) and Filtek Z250 (Z250; 3M ESPE) were polymerized (Optilux 501; Kerr) in polyethylene moulds. Then, the specimens from each group were randomly divided in 2 groups 21 specimens each, and these specimens were post-cured 7 minutes at 120°C with simultaneous light exposure (Coltene D.I-500) (MP; Z250P). After 24 hours storage at 37°C, the specimens were polished with 2500 grit SiC paper, followed by 1µm diamond paste. 21 porcelain specimens (E;Empress II; Ivoclar) were prepared with the same diameter and thickness as the composites, and were glazed.*

Prophylaxis pastes Detartrine (D; Septodont) and Topex (T; Sultan) were applied with brush to the composite and porcelain specimens for 12 seconds, by renewing them every 6 seconds. Specimens which did not exposed to prophylaxis procedures were used as control groups (n=7). The mean surface roughness (Ra; µm) of the control group specimens and prophylaxis pastes Detartrine (n=7) and Topex (n=7) applied groups was determined using a surface profilometer (Perthometer M1;Mahr). Data were analyzed using one-way ANOVA and Tukey's post hoc test.

Results: *For all materials, except glazed porcelain, prophylaxis pastes resulted in a significant surface roughening when compared to the control group (p<0.05); however, the differences between the 2 prophylaxis pastes were not significant (p>0.05). There was not any significant difference between the Detartrine applied groups in all materials (p>0.05), though between Topex applied groups the least surface roughness was obtained with MPT and ET (p<0.05).*

Conclusion: *Prophylaxis pastes increased surface roughness of composites, whereas they did not have any effect on porcelain. Post-curing did not affect the surface roughness of Filtek Z250; however, Miris responded positively in the Topex prophylaxis paste applied group.*

Keywords: Prophylaxis, Surface Roughness; Material, restorative

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ORIGINAL PAPER (OP)
Balk J Stom, 2009; 13:153-160

Introduction

The removal of stains and plaque from all accessible tooth surfaces is a routine part of the hygiene maintenance therapy[21,23]. This procedure is usually performed using a variety of prophylaxis pastes and rotary rubber cups or brushes as carriers. Commercially available prophylaxis pastes are typically composed of a mixture of binder (or thickener), humectant (to retain moisture and stabilizes the preparation), colouring agent, preservatives, fluoride, flavouring, and a range of abrasive grades from coarse to fine[17]. Ideally, prophylaxis pastes should combine good cleaning ability with simultaneous polishing. In addition to this, the agent should cause minimal abrasion of dental hard tissues[3,14], as well as of dental restorations[26]. However surface finish of dental restorations has been shown to be affected due to the applications[16,17,22,26], because many clinicians use only one prophylaxis paste, although patients present a wide range of polishing requirements[16].

The surface finish of dental restorations has a substantial effect on their overall long-term clinical success[12]. Improper hygiene maintenance therapy may reduce the functional and aesthetic life of composite restorations[15]. During these procedures, organic matrix of the composites is preferentially removed[19] as the abrasives in prophylaxis pastes could be harder than the resin matrix and could even be similar in hardness to the fillers[22]. After removal of the organic matrix, filler particles may be exposed and may lead in a rough surface[19]. The increase in surface roughness can contribute to staining, plaque retention, gingival irritation and recurrent caries[24,27]. Due to improved filler technology modifications in the organic matrices and a greater degree of polymerization, composite inlays are becoming increasingly popular as an alternative to porcelain inlays. In addition, post-curing also increases the degree of conversion of resin composites[18], and homogenization of the organic matrix[20]. The increased degree of conversion may lead to improved physical properties[6,9,18]. Therefore, indirect composites may be less susceptible to surface roughening than the direct composite restorations. This study aimed to investigate the effect of 2 prophylaxis pastes on surface roughness of porcelain and 2 hybrid composites that were light cured and additionally post-cured.

Materials and Methods

Technical profiles of the materials used in this study were listed in table 1. 42 specimens from each composite, Miris (M; Coltene) and Filtek Z250 (Z250; 3M ESPE), were polymerized according to the manufacturer's instructions using a light curing unit (Optilux 501; Kerr) with 700mW/cm^2 light intensity in polyethylene moulds, with 2 mm in thickness and 8 mm in diameter. Then the specimens from each group were randomly divided in 2 groups, 21 specimens of each, and these specimens were post-cured 7 minutes at 120ºC with simultaneous light exposure (Coltene D.I-500) (MP; Z250P). After 24 hours storage at 37ºC, the specimens were polished with 2500 grit SiC paper followed by 1µm diamond paste. 21 porcelain specimens (E; Empress II; Ivoclar) were prepared with the same diameter and thickness as the composites, and fired according to the manufacturer's instructions in Empress II EP 600 Combi (Ivoclar/ Vivadent) oven, and were glazed.

Prophylaxis pastes Detartrine (D; Septodont) and Topex (T; Sultan) were applied with brush to the composite and porcelain specimens for 12 seconds, by renewing them every 6 seconds. A new brush was used for each material-treatment combination. Specimens which did not exposed to prophylaxis procedures were used as control groups (n=7). To minimize the effects of operator variability, all the prophylaxis paste applications were carried out by a single person with a single, slow speed handpiece at 2,000 rpm. The surface roughness of the control group specimens and prophylaxis pastes Detartrine (n=7) and Topex (n=7) applied groups was determined using a surface profilometer (Perthometer M1;Mahr), set for a tracing length 1.5mm and a cut off value of 0.25mm. Each sample was rotated 120^0 to record three readings per surface, and an average value of this 3 reading was recorded for each specimen. The instrument provided a readout of average surface roughness Ra per tracing in microns. Ra is the arithmetic average height of roughness component irregularities from the mean line measured within the sampling length. Data were analyzed using one-way ANOVA and Tukey's post hoc test.

Table 1. Technical profiles of the materials used in the study

Materials	Composition				Manufacturer
	Filler type	Average filler size	Filler volume (%)	Resin system	
Miris	Silanized stroncium glass, silanized barium glass, hydrophobic silisic acid	0.6µm	58	Bis-GMA Bis-EMA, TEGDMA	Coltene
Filtek Z250	Silica, zirconia	0.6µm	60	Bis-EMA (6), TEGDMA, UDMA	3M ESPE
Empress II	SiO2 (57-80%),Al2O3 (0-5%), La2O3 (0.1-6%), MgO (0-5%), ZnO (0-8%), K2O (0-13%), Li2O (11-19%),P2O5 (0-11%)				Ivoclar
Detartrine	Silica, 35 % formaldehyde solution				Septodont
Topex	1.23 % APF				Sultan

Representative scanning electron micrographs were taken from each group, showing surface roughness similar to the mean surface roughness of the corresponding group. The specimens were dried, gold-sputter coated, and observed using a scanning electron microscope (JSM 6335F; JEOL Ltd, Tokyo, Japan).

Results

The mean surface roughness of the control and prophylaxis pastes applied groups are shown in table 2. No significant difference in surface roughness was achieved among the control groups of the composites (Miris, Miris P, Filtek Z250 and Filtek Z250 P) - $p>0.05$, whereas Empress II control yielded statistically higher surface roughness than the composites. ($p<0.05$; Tab. 3). For all materials, except glazed porcelain, prophylaxis pastes resulted in significant surface roughening when compared to the control group ($p<0.05$); however, the differences between the 2 prophylaxis pastes were not significant ($p>0.05$). There was not any significant difference between the Detartrine applied groups in all materials ($p>0.05$), though between Topex applied groups, the least surface roughness was obtained with MPT and ET (Tab. 3; $p<0.05$).

Scanning electron micrographs of Miris, as well as of Filtek Z250 control groups, regardless post-curing, revealed smooth surfaces (Fig. 2a; Fig. 3a; Fig. 4a; Fig. 5a), whereas Detartrine and Topex prophylaxis paste applied groups showed many irregularities (Fig. 2b,c; Fig. 3b,c; Fig. 4b,c and Fig. 5b,c), showing protruding (Fig. 3b and Fig. 5b) and displacement (Fig. 3c; Fig. 5c) of the filler particles and scratches on the surface (Fig. 2b,c).

Scanning electron micrographs of the control and prophylaxis paste applied porcelain surfaces revealed smooth surfaces (Fig. 6a-c).

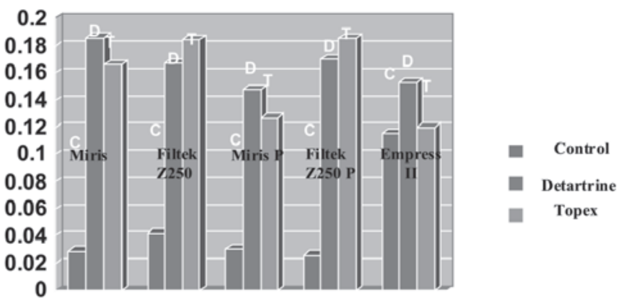
Table 2. Mean surface roughness values (Ra; µm) of the control and prophylaxis pastes applied groups

Group	Miris	Filtek Z250	Miris P	Filtek Z250 P	Empress II
Control	0.029±0.013	0.042±0.01	0.03±0.008	0.026±0.008	0.116±0.028
Detartrine	0.186±0.035	0.167±0.013	0.148±0.013	0.170±0.014	0.153±0.051
Topex	0.166±0.018	0.184±0.031	0.127±0.014	0.185±0.013	0.120±0.059

Table 3. Results of Statistical Analysis

Group	Differences
Control	Miris^a = Miris P^a = Filtek Z250^a = Filtek Z250 P^a < Empress II^b
Detartrine	Miris D^a =Miris PD^a = Z250 D^a = Z250 PD^a =Empress II D^a
Topex	Miris T^a = Z250 T^a = Z250 PT^a > Miris PT^b = Empress II T^b

Materials identified by different superscript letters in each row are significantly different ($p<0.05$) - one-way ANOVA and Tukey's post hoc test



Figureureure 1. Mean surface roughness values (Ra; µm) of the control and prophylaxis pastes applied groups

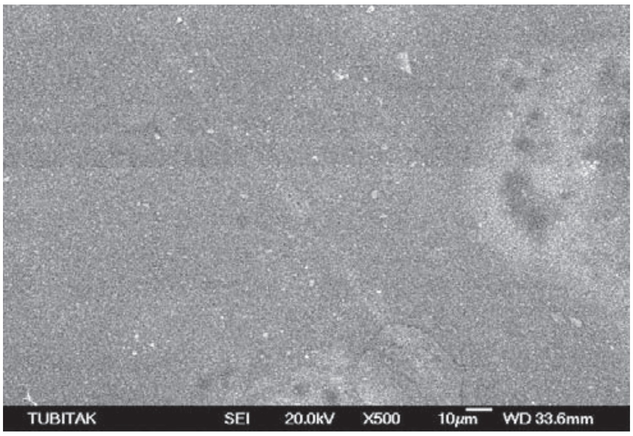


Figure 2a. Scanning electron micrograph of Miris control group showing a very smooth surface

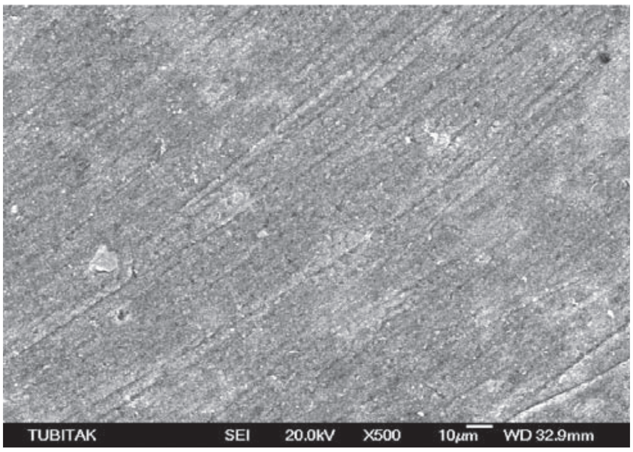


Figure 2b. Scanning electron micrograph of Miris Detartrine group. Many deep scratches on the surface were evident (compare Figure 3a)

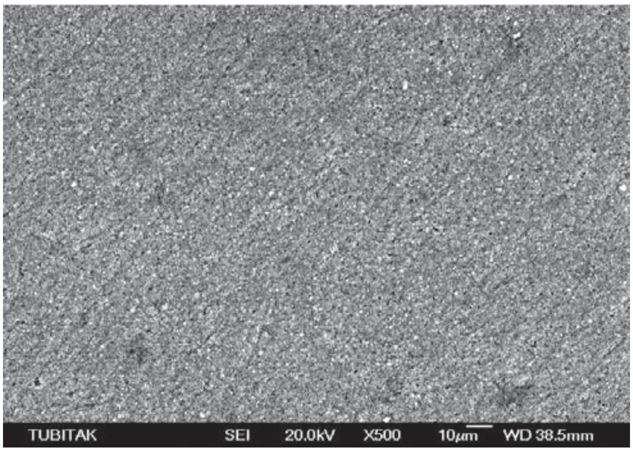


Figure 2c. Scanning electron micrograph of Miris Topex group. The surface revealed protruded filler particles with superficial scratches

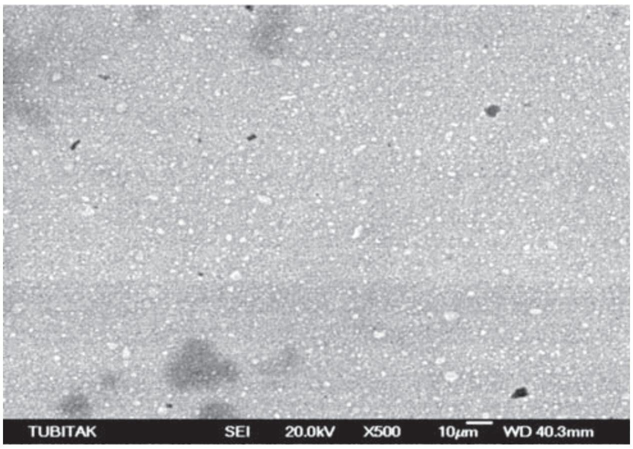


Figure 3a. Scanning electron micrograph of Filtek Z250 control group showing a smooth surface

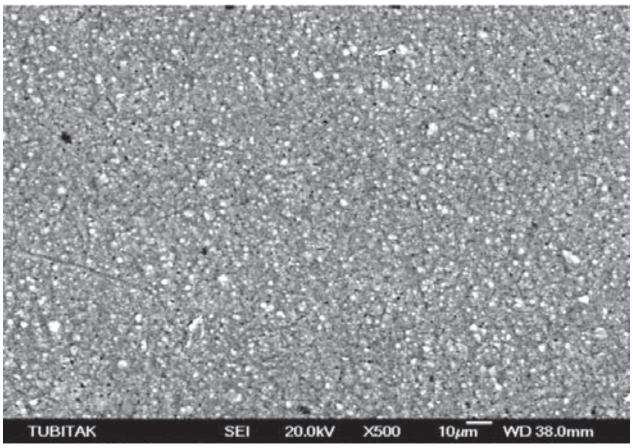


Figure 3b. Scanning electron micrograph of Filtek Z250 Detartrine group. Note the pronounced exposure of filler particles (compare Figure 3a)

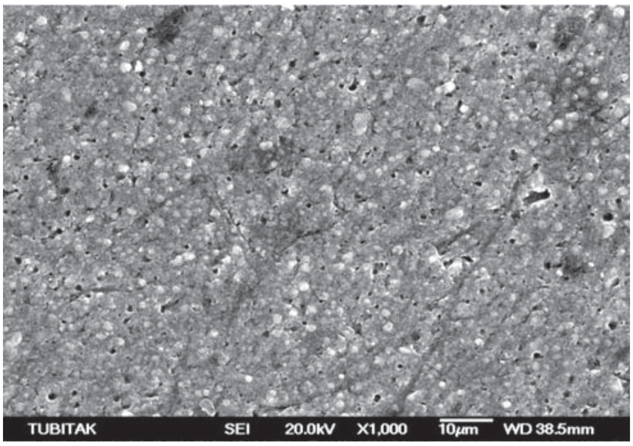


Figure 3c. Scanning electron micrograph of Filtek Z250 Topex group. Filler particles were displaced

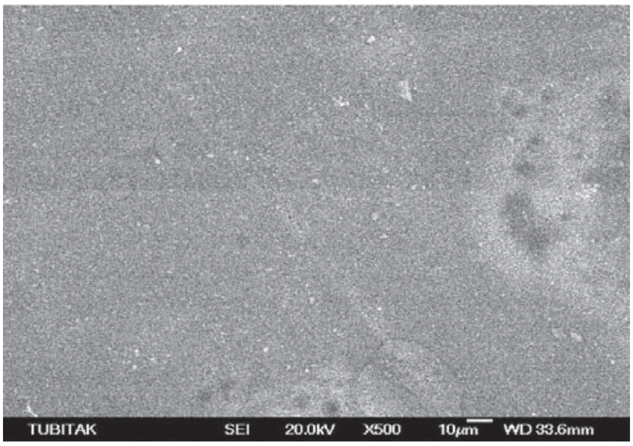


Figure 4a. Scanning electron micrograph of Miris post-cured control group. The surface was very smooth and similar to the Miris control group (Figure 2a)

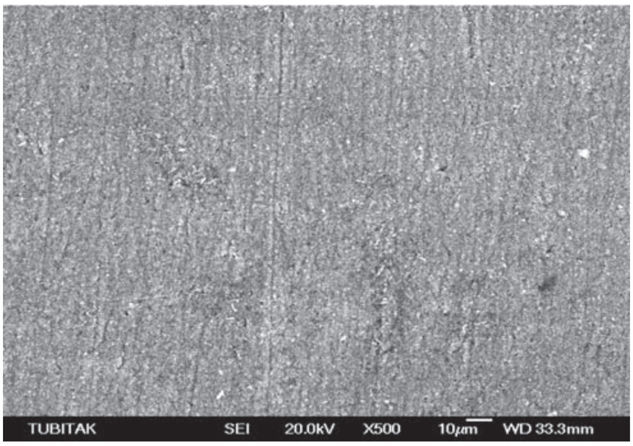


Figure 4b. Scanning electron micrograph of Miris post-cured Detartrine group. Smooth scratches on the surface were evident but not as deep as the Miris Detartrine group (Figure 2b)

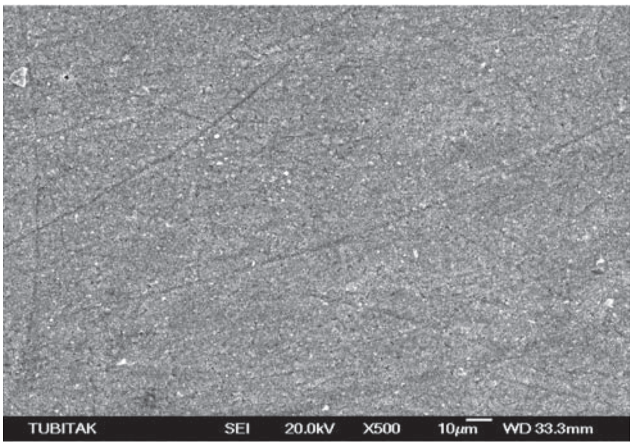


Figure 4c. Scanning electron micrograph of Miris post-cured Topex group. Scratches on the surface were evident; however, filler particles were not protruded (compare Figure 2c)

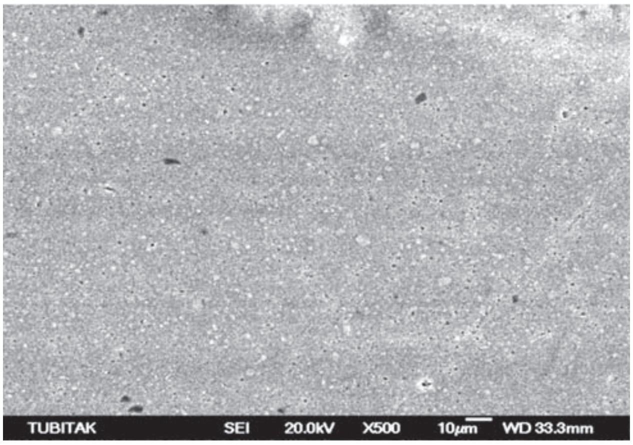


Figure 5a. Scanning electron micrograph of Filtek Z250 post-cured control group showing a smooth surface

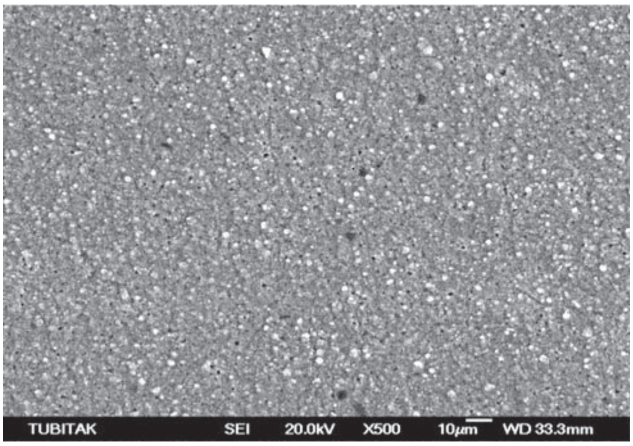


Figure 5b. Scanning electron micrograph of Filtek Z250 post-cured Detartrine group revealing protruding of filler particles

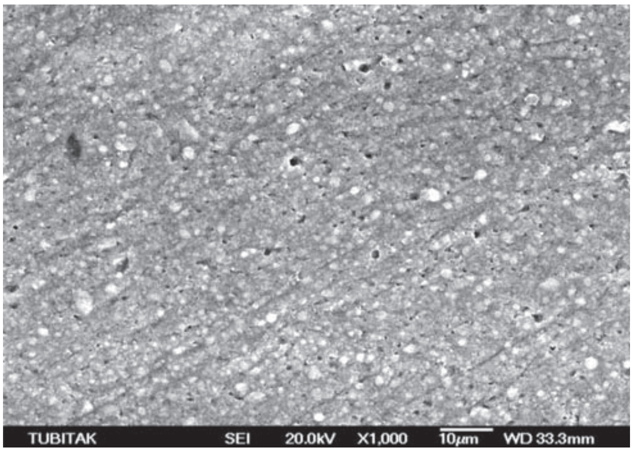


Figure 5c. Scanning electron micrograph of Filtek Z250 post-cured Topex group showing displacement of the fillers

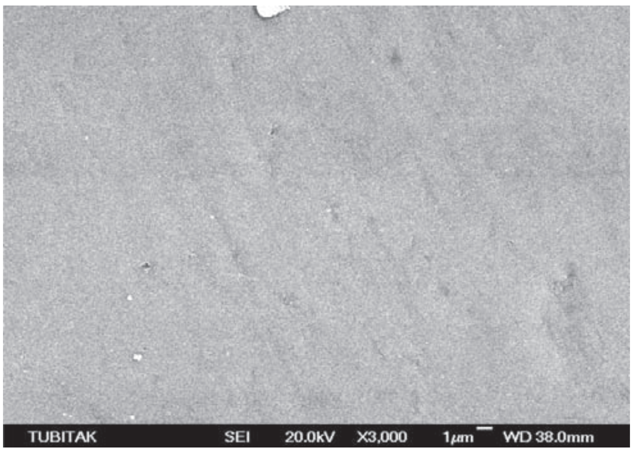


Figure 6a. Scanning electron micrograph of Empress II control group showing a smooth surface

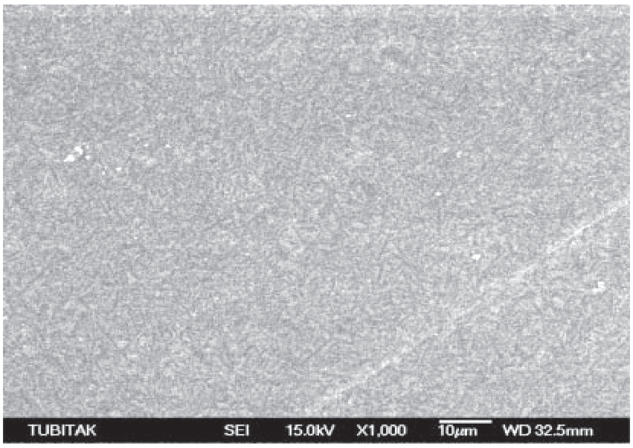


Figure 6b. Scanning electron micrograph of Empress II Detartrine group

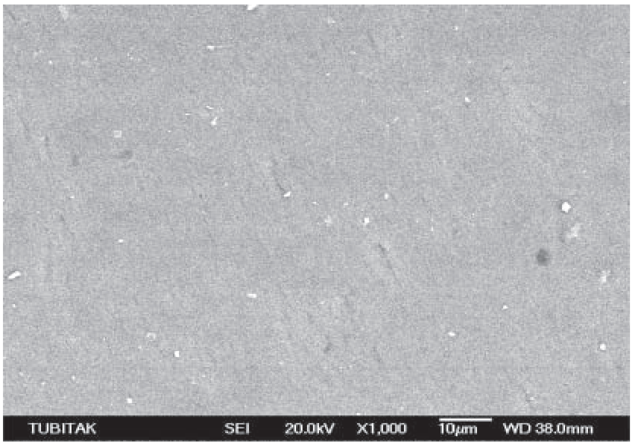


Figure 6c. Scanning electron micrograph of Empress II Topex group

Discussion

Composition, application force and application time of the prophylaxis pastes, as well as the structure of the restorative materials, may affect the surface roughening of the restorations during hygiene maintenance therapies. Prophylaxis pastes content are similar to the dentifrices. Among the other ingredients, Detartrine consist of silica abrasives and 35% formaldehyde solution, and Topex 1.23 APF. For minimizing the effects of operator variability, in this study, all hygiene maintenance procedures were carried out by a single person, using a slow speed handpiece at 2,000 rpm, and the treatment time was fixed at 12 seconds. Structure or composition of the restorative material is influenced by its inorganic and organic content. Both Filtek Z250 and Miris are hybrid type composite resins, with a mean particle size of 0.6µm. However, they differ in their inorganic particle type and organic matrixes. Filtek Z250 contains 60% volume silica and zirconia filler particles whereas Miris has 58% glass particles in its content (Tab. 1). Empress II porcelain has a homogenous structure and was used as a reference material.

In order to determine the effect of prophylaxis pastes on surface roughness of different restorative materials, the initial surface roughness should be standardized and the obtained values should be close to the data, which is obtained with the mylar strip Ra = 0.04 µm. Therefore, in this study, before prophylaxis paste application, all composite specimens were polished with 2500 grid SiC paper followed by 1µm diamond paste, and the obtained Ra values of the specimens were in range of 0.02-0.04 µm, which simulates finishing under mylar strip[17]. Surface roughness data indicated that the effect of prophylaxis pastes was material dependent. Irrespective from the curing method (light cured or light cured and then post-cured), tested composite materials Miris (Figs. 2b,c and 4b,c) and Filtek Z250 (Figs. 3b,c and 5a,b), yielded significantly higher surface roughness after prophylaxis paste application compared to their control groups (Figs. 2a and 4a), whereas Empress II porcelain (Fig. 6a-c) was not significantly affected (Tab. 2). Scanning electron micrograph observation revealed that Miris as well as Filtek Z250 control groups, showed smooth surfaces regardless post-curing (Figs 2a, 3a, 4a and 5a), and prophylaxis pastes Detartrine and Topex applied groups revealed many irregularities (Figs. 2b,c; 3b,c; 4b,c and 5b,c). Detartrine prophylaxis paste caused deep scratches on the Miris surfaces (Fig. 2b), whereas Topex resulted in protruding of the fillers (Fig. 2c). On the other hand, although it did not result in significant less roughening ($p>0.05$), Detartrine caused smoother scratches on the Miris post-cured group (Fig. 4c) when compared to the Miris Detartrine group (Fig. 2b). In comparison to the Miris Topex group (Fig. 2c), Miris post-cured Topex group (Fig. 4c) did not yield protruding of the filler particles, and only some smooth scratches were evident on the surface, which resulted in significantly less surface roughening ($p<0.05$). Surface topography of Filtek Z250 and Filtek Z250 post-cured groups were similar after prophylaxis pastes application. Filler particles of both groups were protruded after Detartrine application (Fig. 3b; Fig. 5b) while Topex caused displacement of the fillers (Figs. 3c and 5c). Scanning electron micrographs of the control and prophylaxis paste applied porcelain surfaces revealed smooth surfaces (Fig. 6a,b,c), which is consistent with their roughness data (Tab.2).

Prophylaxis paste applications abraded the composite surfaces with a three-body wear process[17]. Three-body wear involves the process of resin matrix loss between filler particles and subsequent dislodgement of the filler[4]. Post-curing has been found to enhance composite resin's physical properties, such as surface hardness[8], tensile strength[6] and flexural strength[1], and to increase the degree of conversion[2]; however, the response of mechanical properties to post-curing changed to levels identical to those of the light cured groups when the specimens were subjected to water storage after curing[10]. One advantage that remained unchanged was the increased extent of cure over the light-cured group[13]. The degree of cure of the resin matrix influenced the wear process[11] though the effect of post-curing on surface roughness may vary from material to material. Miris as well as Filtek Z250 are based on the monomers BisGMA, TEGDMA and Bis-EMA. In addition to these, Filtek Z250 consist a blend of UDMA. Bis-EMA and UDMA are of higher molecular weight and therefore have fewer double bonds per unit of weight[25]. Post-curing did not affect the surface roughness of Filtek Z250; however, Miris responded positively in Topex prophylaxis paste applied group. This may be due to the fact that initially cured Filtek Z250 has a more homogeneous structure than initially cured Miris. Another explanation for the difference in responsiveness may be due to the difference s in filler type, filler loading (Tab. 1) and bonding of the filler particles to the polymer matrix.

The critical threshold value of surface roughness for the simultaneous increase in plaque accumulation is 0.2μm. Any increase after this critical value, increases the risk for caries and periodontal inflammation[5]. In this study, the application of Detartrine and Topex prophylaxis pastes increased the surface roughness of the composites that were light cured or additionally post-cured though the increase in surface roughness did not reach the critical threshold value. However, these results cannot be generalized, as the abrasiveness of the prophylaxis pastes is not standardized and surface roughness increases with subsequent use of applications[22]. Therefore, further re-polishing of the composites might be necessary with subsequent hygiene maintenance therapies. On the contrary, Empress II porcelain did not show any significant surface roughening after prophylaxis paste applications. From this point of view, composite restorations, whether they are post-cured or not, which means whether they are inserted directly or indirectly, might cause aesthetic and biological disadvantages to a greater extent than the porcelain restorations.

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