**1.INTRODUCTION**

Nanotechnology offers unique solutions to resin technology providing new formulations that aestetically offer high translucency, high polish and superior gloss as well as adequate mechanical properties suitable for high stress-bearing restorations (1,2). However, discoloration leading to aesthetic failure and need for replacement is a significant aesthetic problem for direct resin composite restorations. The shades of resin composite restorations may change over time due to inadequate polymerization, exposure to environmental factors, heat, water, food colorants and inherent resin and filler components of the resin composite type (3,4).

It is of fundamental importance to maintain color stability of a resin composite restoration. Proper finishing and polishing of resin composite restorations is a basic step to reach this goal. The final appearance of the restoration should provide an enamel-like luster with reduced surface energy to avoid accumulation of plaque and extrinsic stains.

Surface sealant application after polishing may also be an advanced method to maintain smooth resin composite surfaces. Surface sealants are unfilled low-viscosity resins polymerized on the underlying resin composite surfaces (5). The rationale beneath the application of surface sealant to composite resin filling in surface defects, improving marginal integrity, and increasing resistance to abrasion. Surface sealant may provide better resistance to staining than a polished resin composite by reducing the porosity of the surface and providing a well polymerized surface (6). Recently, a liquid polishing system (BisCover LV, Bisco Inc, Schamburg, IL) was introduced, with the aim of reducing or even eliminating the need for clinical polishing of restorations. BisCover LV is a light-curing resin used to seal restorations, claimed to leave a smooth polished surface without a sticky air-inhibited layer (7).

Tooth bleaching agents used in improving the esthetics of the natural dentition have become increasingly popular. Bleaching has been suggested as an efficient and conservative approach for removing intrinsic and extrinsic stains from teeth. Vital tooth bleaching can be done in the office by the clinician using high concentrations of hydrogen peroxide (HP) or at home by the patient with lower concentrations of carbamide peroxide (CP). During the bleaching treatment, these materials contact not only the teeth but also the restorative materials for extended periods of time. Although in dental literature there are many studies focusing on the effect of bleaching agents on surface roughness and color stability of resin composite restorative materials up to-date there is no study evaluating the effect of staining and bleaching procedures on the physical properties of the resin composite (8).

Thus, the aim of this in vitro study was to evaluate the effect of different staining solutions and bleaching procedure on the color stability and surface roughness of a nano-hybrid resin composite with and without liquid resin polishing. The null hypothesis was that application of surface sealant enhances the color stability and the surface roughness properties of the composite resin restoration.

**2.MATERIAL AND METHODS**

Ninety-six disc-shaped resin composite specimens (Z550 Filtek 3M ESPE, St. Paul, MN, USA, A1 Shade) were prepared using a custom polyethylene mold at a diameter of 10 mm and 2 mm in height. The mold with the composite resin was held between 2 glass slides each covered with a transparent polyester strip and the glass slides were gently pressed together to obtain a flat surface without bubble formation. All specimens were polymerized by a LED light-curing unit (Light intensity: 1000mW/cm2; Smart Lite PS, Dentsply De Trey, Konstanz, Germany), using 20 seconds of exposure to top and bottom surfaces, respectively. The specimens were finished and polished with 600, 800 and 1200-grit silicon carbide abrasive paper, respectively (9).Then they were randomly divided into 2 subgroups (N=48). Liquid resin polish (BisCover LV, Bisco Inc, Schamburg, IL) was applied in one group (RP) and the other group did not receive any liquid resin polish (P). In liquid resin polish applied group (RP), the surface of the specimens were etched with 32% H3PO4 solution (UNI-ETCH, Bisco Inc) for 15s, rinsed with water for 15s and dried with air syringe. After then, one thin coat of sealant was applied, air thinned to distribute evenly and light-cured with a light curing unit following the manufacturer’s instructions. Then all prepared specimens were stored in distilled water for 24 hours before baseline color assessment and surface roughness evaluation.Color measurements of all specimens were performed according to the CIE L\*a\*b\* color scale (Commission Internationale de l’Eclairage) with colorimeter(Minolta CR 321, Ltd. Radiometric Instruments Operations, Osaka, Japan). All the specimens were wiped dry using tissue paper and then placed in the colorimeter. The L\*, a\*, and b\* values of each specimen were measured thrice. The color difference, ΔE, was calculated from the mean L\*, a\*, and b\* values for each specimen using the following formula (10,11).

ΔE(L\*a\*b\*)=[(ΔL\*)2+(Δa\*)2+(Δb\*)2]1/2,

Where ΔL\*, Δa\*, and Δb\* are the difference in the L\*, a\*, and b\* values, respectively.

Surface roughness of each specimen was measured using a profilometer (Mitutoyo Surftest SJ-201 Surface Roughness Tester, Mitutoyo Corporation, Tokyo, Japan) whose needle was positioned on the specimen surface, moved at a constant speed of 0.05mm/s, using a cut-off of 0.25mm and roughness tracings were taken on each surface with three random readings (Ra; roughness average). All the color and surface roughness evaluations were obtained by one operator.

Each group (RP and P) was further divided into 4 sub-groups (n=12) to be immersed

in a control and three different staining solutions (distilled water, ice tea, red wine and coca cola). Distilled water served as control solution. The specimens of each group were immersed in vials containing 5mL of distilled water, ice tea, red wine or coca cola for 1 week at room temperature and the solutions were renewed daily. After completion of immersion cycle in staining solutions, the samples were washed with distilled water and stored in distilled water for 24 hours.

Color assessment and surface roughness evaluation were re-evaluated by the same operator as previously described at the baseline measurements.

After the measurements, all the specimens were subjected to office bleaching procedure (35% hydrogen peroxide, Pola Office Bleaching, SDI Limited, Bayswater, Victoria, Australia) which was applied for 24 minutes (three times, 8 minutes) following the manufacturers’ instructions. The samples were kept in distilled water for 24 hours and their color and surface roughness were re-evaluated by the same operator.

*Statistical analysis*

Statistical analysis was accomplished by the software SPSS for Windows Version 15.0 Data were subjected to analysis of variance for repeated measures among the groups. Multiple comparisons were evaluated by Bonferroni test (p<0.05).

**3.RESULTS**

**3.1 Surface Roughness:**

The mean surface roughness values (Ra) and standard deviations of RP and P groups measured at baseline, after staining and after bleaching procedures are summarized in Table 1. The staining and bleaching procedures didn’t cause statistically significant changes in surface roughness values for both RP and P groups (p>0.05); however, RP groups presented statistically significantly higher surface roughness values than P groups with respect to each staining solution including the control group (p<0.001 for each staining solution).

**3.2. Color Change:**

Table 2 shows the means of the color change values (ΔE) of RP and P groups after staining and bleaching procedures. ΔE values higher than 3.3 were evaluated as visually perceptible and clinically unacceptable (ΔE>3.3) (12-14). Red wine staining revealed a visually perceptible staining effect on RP group (ΔE=4,47±1,40). The discoloration values (ΔE) of red wine group after staining procedure were significantly different from the other staining solutions for both RP and P groups (p<0.05). However, bleaching procedure after red wine staining caused statistically significant color change for both RP and P groups (p<0.05).

When liquid resin polish group (RP) was compared with polish group (P) with respect to staining solutions it was shown that red wine and cola caused significantly higher ΔE values in RP groups than P groups (p<0.05).

**4. DISCUSSION**

The effect of surface sealant application on the color change and surface roughness values was assessed with a colorimeter and profilometer, respectively. The null hypothesis was rejected because the surface sealant didn’t enhance the color stability and the surface roughness properties of the composite resin restoration.

In last decades, bleaching has become a routine treatment for improving esthetics. Bleaching agents affect the color lightening of discolored tooth structure through decomposition of peroxides into free radicals. The free radicals result in a breakdown of the large pigmented molecules in the enamel into smaller, less pigmented molecules through either oxidation or reduction. It is unavoidable to prevent restorations from bleaching agent exposure during bleaching procedure. The mechanism of how bleaching materials affect restorative material is not clear, but presumably this may be due to hydrogen peroxide, which may penetrate the surface and attack the filler (15).

In the present study the CIE L\*a\*b\* color system was used for measuring color of restorative materials before and after bleaching and surface sealant applications. This is a 3-dimensional color measurement system, where L\* refers to the lightness coordinate, which has a value ranging from 0 for perfect black to 100 for perfect white, and a\* and b\* are the chromacity coordinates on the green-red (-a\*=green; +a\*=red) and blue-yellow (-b\*=blue; +b\*=yellow) axes, respectively (16-18). Color changes can be calculated using ΔE calculation which previously mentioned.

Tristimulus colorimeters are capable of detecting color differences below the threshold of visiual perception. The value of ΔE represents relative color changes that an observer might report for the materials after immersion in staining solutions or after bleaching procedure. Thus the ΔE is more meaningful than the individual L\*a\*b\* values (19). The ΔE values greater than 3.3 are considered to produce a visually or clinically unacceptable discoloration of the specimen (20).

In the present study, red wine showed higher color change after staining and after bleaching procedure for resin polish applied and polished surface than other solutions (ΔE=4.47±1.40 and ΔE=3.22±0.95 respectively). Color differences of this magnitude have been characterized as unacceptable for in vitro conditions in which optimal lightening was used with monochromatic specimens. The wine used in the study contains 13,5 % alcohol by volume. Aguiar and colleagues, using alcoholic and aqueous solutions to test the susceptibility of restorative materials to staining, showed higher staining mean values for alcoholic than aqueous solutions (21). Other authors, comparing red wine with coffee, water, and cola, reported that the alcoholic solutions caused more discoloration than the non-alcoholic ones (22,23).

Alcohol causes the composite resin surface to soften by removing its polymer structure such as unreacted monomers, oligomers, and linear polymers (24), facilitating the absorption of pigment agents and increasing wear (25,26). In a composite resin, having the same monomer degree of conversion, the resin surface dissolution by ethanol might be more selective in a relatively linear polymer than in one that is expected to have a more cross-linked structure.

Distilled water, ice tea and cola caused visible color changes that are nonetheless clinically acceptable (ΔE from 1.79 to 2.58 after staining; ΔE from 1.55 to 1.82 after bleaching). The low pH can negatively affect the surface integrity by softening the matrix, causing a loss of structural ions and affecting the wear resistance of dental materials. The low pH of cola soft drinks (2.36) did not influence the color change, since higher pH solutions such as red wine (3.41) cause greater staining (27). Cola soft drink contains carbonic acid (28) and phosphoric acid (29); red wine, tartaric acid (30) thus the different acids found in the beverages could explain such results.

Polishing procedures remove the oxygen inhibition layer which is more prone to staining than the polished layers from the resin composite surface. However liquid resin polish application creates a new oxygen inhibition layer on the polished surface. In our study all RP groups showed higher ΔE values than P groups after staining procedure. Newly occured oxygen inhibited layer on the surface may be responsible for these results. Liquid resin polish used in this study (BisCover LV) contains dipentaerythritol pentaacrylate esters as monomer. These monomers may be more prone to staining than the monomers used in Filtek Z550 resin composite formulation.

In the present study, surface roughness values of all RP groups were significantly higher than P groups (p<0.001). Higher ΔE values of resin polish applied groups may be related to rough surfaces occurred after resin polish application. In accordance with the results of Table 1, the immersion in staining solutions and bleaching procedure had no effect on the roughness of composite resin or resin polish, nevertheless the resin polish presented higher surface roughness values than composite resin. The capacity of resin polish to mask surface defects of resin composite was observed, but it was difficult to obtain regular surface with liquid polish. This report may support our assumption that surface properties of specimens of resin composites; however, further study is needed for this observation (31).

Nano-hybrid composites are formulated with both nanomer and nanocluster filler particles (1). They offer high translucency, high polish and superior gloss as well as adequate mechanical properties suitable for high stress bearing restorations (1,2). Lopes et al, investigated effects of surface sealant application on the surface roughness values of a nanofiller composite in their in vitro study. To this aim they applied BisCover LV and two other resin polish on a nanofiller composite. At the end of the study they observed a wave texture probably due to evaporation of the solvent from the material prior to polymerization on BisCover LV applied groups microscopically. Surface roughness values of BisCover LV applied groups were higher than polished only groups. These findings are in accordance with our findings. Cilli et al*.* also reported these findings on Biscover surface (32).

As it had been mostly reported that bleaching increases the surface roughness of resin composites (15, 33-35), it might be expected that composite restorations would stain more easily after bleaching because rough surfaces mechanically tend to retain surface stains more than smoother surfaces (36,37). However, in the present study, bleaching was found to have no effect on the surface roughness values and staining susceptibility of the resin when immersed in three different staining solutions.

**Conclusion:**

Within the limitation of this in vitro study, the following conclusions could be drawn:

1. Staining and whitening procedures didn’t significantly affect surface roughness values

of the nano-hybrid composite with or without surface sealant application.

2. Staining solutions except red wine caused clinically acceptable discoloration values

(∆E < 3.3).

3. Bleaching procedure after red wine staining caused statistically significant color

change for both RP and P groups.

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