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ORIGINAL RESEARCH

Evaluation of the Effect of a Home-bleaching Agent on the Surface Characteristics of Indirect Esthetic Restorative Materials: Part I—Roughness

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ABSTRACT

Background: Pressing esthetic demands of good looking make people undergo bleaching procedures. However, the effect of bleaching agents on esthetic restorative materials with different surface preparations has been poorly studied.

Aim: The aim of this study was to examine the effect of a home-bleaching agent (carbamide peroxide: CP 38%) on the surface roughness of the polished fiber reinforced composite (FRC), overglazed, autoglazed, or polished ceramic samples.

Materials and methods: Twenty standardized cylindrical specimens were made of each of the following groups: overglazed, autoglazed, polished porcelain and also FRC. The test specimens exposed to the CP 38%, 15 minutes, twice a day for 2 weeks according to the manufacturer's recommendation. Six samples from each group were selected randomly to form negative controls. Surface roughness measurements (Ra, micrometer) for baseline, test and control specimens were performed by use of a profilometer. Paired t-test, Mann-Whitney test, and Kruskal-Wallis test were used for statistical analyses.

Results: The data showed that bleaching with CP 38% significantly increased the surface roughness of all the test samples ($p < 0.05$). The type of surface preparation caused significant differences between the susceptibility of porcelain subgroups to bleaching ($p < 0.05$). The polished porcelain specimens showed the highest changes after bleaching.

Conclusion: CP 38% significantly increases the surface roughness of the porcelains and FRC. The type of surface condition affects the amenability of the porcelain surface to the bleaching agent. Glazed porcelains were more resistant to roughness than the polished porcelains and also the composite.

Clinical significance: Roughening of porcelain and FRC occur following bleaching procedure. No special surface preparation of indirect esthetic restorative materials can completely preserve these materials from adverse effects of bleaching agents.

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INTRODUCTION

Smile look is amongst very important and impressive issues in esthetic that is affected by several different aspects such as tooth shape, texture, position and color. Tooth color is the result of the volume scattering of the light, i.e. the illuminating light follows highly irregular light paths through the tooth before it emerges at the surface and reaches the eye of the observer.[1,2] Over the lifetime of the tooth, there are many factors that influence both the color and the brightness of the teeth. There are many approaches to improve tooth discoloration, ranging from conservative procedures to invasive methods like prosthetic interventions.

Tooth bleaching was reported in the literature as an esthetic treatment option for adults.[1] While a prolonged contact between bleaching agents and dental structure is necessary to allow the oxidation process, interaction between the bleaching agents and esthetic restorative materials is of critical importance.[3] The oxidation procedure and the resulting acidic pH has been considered to be a possible basis of adverse effects.[4] Surface alterations such as increased porosity or decreased hardness are clinically important since these deleterious impacts can imperil the esthetic and durability of restoration and put at risk the health of the oral structures in long-term.[5] For instance, if the bleaching procedure causes roughening of the restoration surface, this roughness is potentially prone to accumulate the extrinsic stains, dental plaque and is subjected for the bacterial adhesion. Subsequently, plaque accumulation will cause periodontal disease and dental caries. The increased wear of the opposing tooth or restoration and unesthetic emergence have also been related to increased surface roughness of the restorations.[5-8]

There are broad controversies in the literature regarding the effect of the bleaching agents on restorations. Composite organic matrix is susceptible to the oxidation reaction, therefore surface roughening is expected to expose resins to oxidizing bleaching agents in long-term. However, there are studies that report no alteration[6-8] in surface roughness of composite resins, although increasing in roughness has been reported as well.[9,10] The roughness of porcelain has also been reported to be increased,[5,11,12] or to be remained unchanged.[10,13,14]

Turker and Biskin[10,14] found no significant changes in surface roughness values for the feldspathic porcelain after exposure to CP. The same result was reported in an SEM investigation by Schemehorn et al.[13] when applying a 6% hydrogen peroxide (HP) gel on feldspathic porcelain and also by Haywood and Swift.[15,16] In an *in vitro* study,[5] feldspathic porcelain had a rougher surface after 21 days of exposure to 10 and 35% CP. Zaki and Fahmy[17] discriminated autoglazed from overglazed ceramic restorations. They showed that an office bleaching procedure with 35% CP followed by an home bleaching technique with 15% CP significantly increased the surface roughness, but did not affect autoglazed ceramic restorations. Kamala and Annapurni[11] investigated the effect of 3 acidic solutions (included CP 16%) on the surface roughness of the ceramics. They reported that acidic solutions significantly etched the ceramic surfaces; furthermore they showed that polished surface was smoother than glazed surface and the polishing of the ceramics increased its surface resistance toward the etching effect of acids. Butler,[12] showed that 10% CP etched the auto-glazed surface of aluminous porcelain but had no effect on the polished surface of study samples.

Such controversies impose further investigations on the effect of the bleaching agents on surface properties of restorative materials to guarantee their safety or to consider preventive care if the possibility of adverse effects exists.

This study aimed to evaluate the effect of a home-bleaching agent on the surface roughness of the fiber reinforced composite, autoglazed, overglazed or polished porcelain specimens.

MATERIALS AND METHODS

The specimens' preparation was divided into 3 phases: In the first phase standardized cylindrical metallic molds were fabricated and for the second phase the veneering materials were condensed into the molds. In the third phase surface preparation of the veneering material was done.

Three groups of feldspathic porcelain (n = 20 per group) were prepared (Duceram love-DeguDent GmbH-DENTSPLY, Germany), according to manufacturer's instructions. Following calliper control, the defects were adjusted with corrective add-on porcelain firing. After air cooling at room temperature, the samples ground flat, air particle abraded by use of 50 μm aluminum-oxide powder, and wet polished with progressively finer grit aluminum oxide abrasive papers.

For surface preparation phase, the porcelain samples were divided into three groups: The overglazed porcelain (OP) and the autoglazed porcelain (AP) groups were glazed following the manufacturer's instructions. For the third group, polished porcelain (POP), the samples were polished. The polishing process was done with medium, fine, and superfine Sof-Lex (3M) disks on a slow-speed hand-piece according to the manufacturer's instructions.

For the forth group: FRC, the condensable veneering composite from the fiber reinforced composite system ($Adoro_{SR}$-Ivoclar Vivadent, Germany) was packed into the molds. Adoro pastes were applied and cured based on the manufacturer's instructions. Later, the entire veneering surface was covered with SR gel to prevent the formation of air inhibition layer, and the final polymerization was done. After completion of polymerization, each sample was ground flat using tungsten carbide bur, fine diamond and flexible disk on slow-speed hand-piece to remove an air inhibition layer. Then samples were polished by employing silicone wheels, cotton buff and universal polishing paste: emulsion comprising aluminum oxide, aluminum oleate, petroleum distillate and water according to producer's instructions.

All samples were cleaned with 1 minute air-water spray and stored in distilled water at 37°C for 48 hours. Subsequently six samples from each group were selected randomly to form additional negative controls. The roughness tests were carried out for each sample as baseline measurement, so that each sample could be as its own control.

For roughness test, the surface Profilometer (Taylor-Hobson-Rolling Meadows Inc., UK) was used. The traverses of stylus were made longitudinally for each sample, and the quantities reported in μm.

The bleaching procedure was done for each test sample at 37°C. The top-surface of fourteen samples from each group were covered completely with bleaching material (38% CP: DayWhite ACP-Discus Dental, USA) for 15 minutes, twice a day with 3 hours intervals over a period of 2 weeks. Between each bleaching exposure, the exposed specimens were washed with soft brush under running distilled water for 1 minute and kept in fresh distilled water at 37°C until the next bleaching application. The negative controls were stored in distilled water at 37°C that was changed daily after washing the samples with soft brush under running distilled water for 1 minute to mimic the natural conditions. After 2 weeks, roughness tests were carried out for each sample in a similar way to our basic measurements; all readings were performed by the same operator to eliminate inter-operators

bias. The Paired-T-test, Mann-Whitney test, and Kruskal-Wallis test were used for statistical analysis.

RESULTS

Table 1 presents the baseline mean of the surface roughness values (μm), and standard deviation for all groups. Group statistics of baseline measurements showed that the overglazed porcelain had the smoothest surface before bleaching procedure followed by autoglazed samples and polished composite and the later was much rougher. The polished porcelain samples had the roughest surface texture. Tables 2 and 3 present the comparison of roughness mean values within each subgroup. Bleaching with 38% CP significantly increased the surface roughness of all test samples ($p < 0.05$), whereas the control groups did not show statistically significant changes after 2 weeks compared with their baseline quantities ($p > 0.05$). According to the effect size test, the polished porcelain specimens illustrated the highest surface changes after bleaching process, followed by polished composite and autoglazed porcelain. The least change in surface roughness occurred in overglazed porcelain samples, yet all the changes were statistically significant. Table 4 shows that the types of surface preparations cause statistically significant differences between the susceptibility of porcelain subgroups to bleaching agent ($p < 0.05$).

DISCUSSION

In the present study, two types of indirect esthetic restorative material, with different surface treatments have been used (autoglazed porcelain, overglazed porcelain, polished porcelain, and polished FRC) to evaluate the influence of carbomide peroxide 38%, which is equivalent to 13.75% hydrogen peroxide, a mild bleaching agent.

Carbamide peroxide solutions are very unstable and immediately dissociate into their constituents after clinical application on contact with tissue or saliva. Carbamide solution breaks down into hydrogen peroxide and urea. The hydrogen peroxide further degrades into oxygen and water, whereas the urea degrades into ammonia and carbon dioxide. Treatment times for home bleaching vary extensively and depend on how much time per day the patient spends applying the

Table 1: Mean baseline surface roughness values

Groups	*Mean*	*SD*	*Minimum*	*Maximum*
OP	0.02	0.01	0.02	0.05
AP	0.04	0.01	0.01	0.08
POP	0.44	0.18	0.23	0.74
FRC	0.22	0.05	0.13	0.31

OP: Overglazed porcelain; AP: Autoglazed porcelain; POP: Polished porcelain; FRC: Fiber reinforced composite

Table 2: Baseline-control (without bleaching) mean roughness differences

Groups	*Mean*	*SD*	*SE*	*t*	*p*
OP	0	0.008	0.003	0	1
AP	0.003	0.008	0.003	1	0.363
POP	0.025	0.062	0.025	0.979	0.372
FRC	0.003	0.025	0.01	0.326	0.758

OP: Overglazed porcelain; AP: Autoglazed porcelain; POP: Polished porcelain; FRC: Fiber reinforced composite

Table 3: Baseline-test (after bleaching) mean roughness differences

Groups	*Mean*	*SD*	*SE*	*t*	*p*	*Eff. Size Mean diff/SD*
OP	–0.006	0.008	0.002	–2.85	0.013	0.763
AP	–0.007	0.009	0.002	–2.92	0.012	0.781
POP	–0.125	0.101	0.027	–4.61	0	1.234
FRC	–0.019	0.024	0.006	–2.91	0.011	0.789

OP: Overglazed porcelain; AP: Autoglazed porcelain; POP: Polished porcelain; FRC: Fiber reinforced composite

Table 4: Statistical analysis of porcelain subgroups

Groups	*Median*	*Mean ± SD*	*p Based on Kruskal-Wallis test*	*Significant pairwise comparisons Based on Mann-Whitney test*
OP-baseline	0	0.006 ± 0.008	<0.001	OP *vs* AP (p = 0.001)
AP-baseline	0.010	0.007 ± 0.009	<0.001	OP *vs* POP (p = 0.005)
POP-baseline	0.140	0.125 ± 0.101	<0.001	AP *vs* POP (p = 0.001)

OP: Overglazed porcelain; AP: Autoglazed porcelain; POP: Polished porcelain; FRC: Fiber reinforced composite

suggested technique.[17-19] In this study the samples exposed to the CP, 15 minutes, twice a day for 2 weeks according to manufacturer's instructions. This was in contrast to several other studies, where materials were exposed continuously to bleaching products for several days to simulate cumulative effects over a period of time.[20-22] The frequency of applying bleaching agents may contribute to the disparity in the reported results.

In the present study bleaching agents increased surface roughness of FRC specimens significantly which is in agreement with the results reported by Bailey,[9] Turker,[10] McInnes,[23] Cooley,[24] Wattanapayungkul,[25] and Gurgan.[26] Langsten has attributed such change to Bis-GMA matrix softening by acidic solution.[8] Fillers are probably inert even in an extremely acidic environment. Since roughening was suggested to result from erosion of matrix, the consequent debonding of resin-filler interfaces would lead to dislodgment as to elution of fillers. Thus, the higher the volume and the size of leached particles, the rougher the resulting surface.[5,27-29] However, the composite investigated in our study was indirect composite of the FRC system, which has not been studied before. This study shows that the Urethane dimethacrylate (UDMA) matrix experiences the same reactions.

The roughness of porcelain samples exposed to bleaching material in this study increased significantly. The polished porcelain specimens showed the highest surface changes after bleaching process, and the autoglazed samples carried on the least impact on surface roughness. This result was in contrast with the Butter's, and Kamala's studies.[11,12] They showed the polished surface presented more resistance to etchant effect of acidic solutions like bleaching materials. Zaki[17] reported that the autoglazed ceramics were more resistant to roughness rise after exposure to bleaching agents than overglazed surface which is in agreement with our study. However, there are several studies that reported no significant surface roughness changes after bleaching procedure.[10,13-16] The surface roughness changes in ceramics have been attributed to the reduction of (SiO_2) and (K_2O_2) molecules.[5] Since, the bleaching agent caused more changes in surface properties of polished specimens, it seems that the glazed surface is more resistant. However, because all changes were significant, it is apparent that even protective glaze layer cannot preserve the porcelain from all the environmental changes.

The present study showed notable home bleaching influence on ceramic (regardless the type of the surface conditioning), and fiber reinforced composite surface properties. This result is in agreement to several articles and in contrast to several others.[9-17] These evident controversies may be explained, in part, by the differences in experimental methodologies and bleaching agents used. While some researchers have adopted clinically relevant protocols, others have employed continual exposure of restorative materials to the bleaching agents over predetermined time periods. Also it is important to note that results may be substance dependent, as some materials are pH sensitive. Leonard claimed that the pH of the bleaching agents increases after 15 minutes, and concluded that the prolonged contact between the material and bleaching agent causes roughening of material.[18]

As the new bleaching agents with various concentrations and using instructions are introduced and their applications increased due to patients' desires, the concerns about their potential adverse effects on dental restorations and patients' general health increased as well. Dentists should be aware that the physical properties of some dental restorations may be altered by bleaching. They should also make sure that their patients with dental restorations are aware of the changes that may occur during whitening, as well as the possibility that their bleached restorations might need to be polished or even replaced. The clinical relevance of the findings demonstrated in this study is uncertain, however, it seems logical to consider precautionary measures to prevent any side effects until the complete safety of bleaching materials are proved. Because home bleaching agents are easily accessible and their contacts with esthetic restorations are unavoidable, protecting these restorations from contacting bleaching agents and polishing (or reglazing if possible) the restorations after bleaching procedure might be useful.

Further studies (preferably *in vivo* clinical study) are always suggested as new materials and technologies are constantly introduced to dental practice.

CONCLUSION

The effect of a home-bleaching agent on the roughness of the two different indirect esthetic restorative materials can be concluded to:

- The total mean roughness of the polished porcelain specimens was higher than the glazed specimens before starting the procedure.
- The 38% CP caused significant surface roughening of composite resin and ceramic.
- The type of surface preparation (over-glazing, autoglazing, or polishing) significantly affects the susceptibility of porcelain surface to the bleaching agent.
- Polished porcelain showed the highest change in surface roughness and autoglazed samples showed the least.

CLINICAL SIGNIFICANCE

Roughening of porcelain and FRC occur following bleaching procedure. No special surface preparation of indirect

restorative materials can completely preserve these materials from adverse effects of bleaching agents.

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