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ORIGINAL RESEARCH

Evaluation of the Effect of a Home Bleaching Agent on Surface Characteristics of Indirect Esthetic Restorative Materials—Part II Microhardness

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ABSTRACT

Background: The exponential usage of esthetic restorative materials is beholden to society needs and desires. Interaction between the bleaching agents and the esthetic restorative materials is of critical importance.

Aim: This *in vitro* study has been conducted to evaluate the effect of a home bleaching agent, carbamide peroxide (CP) 38%, on the microhardness of the fiber reinforced composite (FRC), overglazed, autoglazed, or polished porcelain specimens.

Materials and methods: For overglazed, autoglazed, polished ceramics and also FRC cylindrical specimens (n = 20 per group) were prepared. The specimens were stored in distilled water at 37ºC for 48 hours prior to testing. Six samples from each group were selected randomly as negative controls which were stored in distilled water at 37ºC that was changed daily. CP 38% was applied on the test specimens for 15 minutes, twice a day for 14 days. By using Knoop-microhardness tester microhardness testing for baseline, control and test specimens was conducted. Data were statistically analyzed using paired t-test, Mann-Whitney test, and Kruskal-Wallis test.

Results: Home bleaching significantly decreased the surface microhardness of all the test samples ($p < 0.05$), whereas the control groups did not show statistically significant changes after 2 weeks. The polished porcelain and polished composite specimens showed the most significant change in microhardness after bleaching process ($p < 0.05$).

Conclusion: Although the type of surface preparation affects the susceptibility of the porcelain surface to the bleaching agent, no special preparation can preclude such adverse effects.

Clinical Significance: The contact of home bleaching agents with esthetic restorative materials is unavoidable. Therefore protecting these restorations from bleaching agents and reglazing or at least polishing the restorations after bleaching is recommended.

Keywords: Bleaching, Esthetic restorative materials, Microhardness, Porcelain, Fiber reinforced composite.

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INTRODUCTION

Esthetics, by definition, is the science of beauty, the particular detail of an animate or inanimate object that makes appealing to the eye.[1]

The last three decades have witnessed massive changes in dentistry.[2] Perhaps the most significant change was emphasis on esthetics in contemporary dentistry. The appearance of a smile is an important and impressive factor in esthetics which is affected by several different factors like tooth shape, texture, position and color. Since 30 years ago, the teeth were treated predominantly by invasive methods like prosthetic options for esthetic purposes. Today more conservative and economic bleaching methods are granted and tooth bleaching has become a well-liked modality to whiten discolored teeth.[3] With choosing a correct patient and having a careful diagnosis, case selection, treatment planning, and attention to technique; bleaching would be the simplest, least invasive, least expensive way available to lighten discolored teeth.[4]

Close and fairly prolonged contact of bleaching materials with tooth structure and pre-existing restorations, raised apprehensions about their effects on the enamel and restorative materials from the beginning of their introduction. Researchers have shown that home bleaching is a safe technique with regard to its effect on tooth structure,[5-9] but some concerns remain on its possible effect on restorative materials.[10-13] It is not clear if the bleaching agents could harm the quality and longevity of these restorations.

The hardness of the materials is related to their strength, proportional limit and their ability to abrade or to be abraded by opposing dental structures or materials. If any chemical softening be resulted from the bleaching process, the clinical durability of the restorations would be jeopardized.

There is controversy about the impact of low concentrated CP gels on surface microhardness of restorative composite materials. A reduction in microhardness in resin-based composites is expected owing to their organic matrix content, which, according to many authors, is the probable site of the oxidation reaction[15-17] but there is disparity in this field. The hardness of resin-based composites exposed to bleaching products has been reported to be increased,[17-22] decreased,[14,17,23] or remained unchanged.[24-28]

The hardness of porcelain has not been investigated as much as the aforementioned materials however available studies show contradictory results. Polydorou[22,28] found that in-office (38% HP) and at-home (15% CP) bleaching agents did not affect the microhardness of the ceramics 30 days after the bleaching procedure was finished.[28] However, these findings are in conflict with those of Turker[17] who reported significant decreases in the surface microhardness of feldspathic porcelain after a 30-day exposure to CP 10-16% for 8 hours daily. Fahmy[29] showed that practices like glazing, bleaching, and saliva storage have an important effect on microhardness, fracture toughness and crack length of ultra low fusing ceramic.

With this foreword, it appears necessary to further investigate this issue to obtain safe durable results or to find a method to reduce its risks if negative side effects were established.

The aim of this study was to evaluate the effect of a home bleaching agent (CP: 38%) on the microhardness of the FRC, overglazed, autoglazed, or polished porcelain samples.

MATERIALS AND METHODS

In this study, ceramic disks (10 mm diameter, 6 mm thick) were used for standardization.

Preparation of the specimen was carried out in three phases:

In the first phase cylindrical metallic molds were constructed. For this purpose according to Turker et al study[17] two pieces of 6 mm stainless steel disks were held together by a weld. Before welding, four 1 cm diameter holes were bored in one of the plates. In this way holes with a flat and parallel bottom were produced. The metal mold was boxed, and poured with a silicon duplicate impression material in accordance with the manufacturer's directions. Refractory material in a powder: liquid ratio of 3:1 was mixed using a vacuum mixer and poured over the silicon molds using a vibrator. When the material had set, negative investments were removed from the silicon duplicating mold. This procedure was repeated until 80 investments were produced.

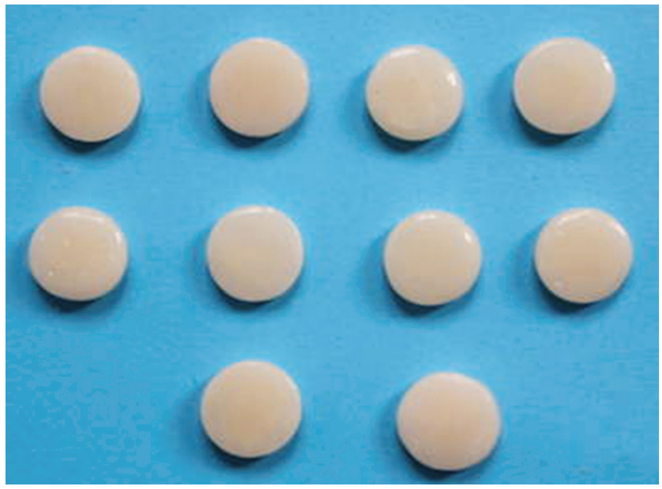

Fig. 1: Ceramic samples

Three groups of feldspathic porcelain (n = 20 per group) were prepared by condensing porcelain (Duceram love-Degu Dent GmbH-DENTSPLY-Germany) into the molds and firing in vacuum furnace according to manufacturer's instructions. The defects were adjusted with corrective add-on porcelain firing. After air cooling at room temperature, the ceramic disks were ground flat and wet polished with progressively finer grit aluminium oxide abrasive papers (Fig. 1).

For surface preparation phase, the porcelain samples were divided into three groups: The overglazed porcelain (OP) and the autoglazed porcelain (AP) groups were glazed in accordance to 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: The condensable veneering composite of the fiber reinforced composite system (Adoro SR-Ivoclar Vivadent-Germany) was packed into the molds. Adoro pastes were applied and cured according to manufacturer's instructions. The entire veneering surface was covered with SR gel to prevent forming an air inhibition layer. 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. They were polished using 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 air-water spray for 1 minute and stored in distilled water at 37ºC for 48 hours. Afterwards, six samples from each group were selected randomly to form negative controls. The microhardness tests were done for each sample as baseline measurement, therefore each sample assumed to be its own control.

Table 1: Mean baseline hardness values

Groups	Mean	SD	Minimum	Maximum
OP	565.92	9.53	552.90	578.00
AP	581.74	20.00	542.90	611.50
POP	566.05	33.74	507.30	623.90
FRC	44.90	8.09	32.60	57.90

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

Table 2: Baseline – control mean hardness differences

Groups	Mean	SD	SE	t	p
OP	–2.73	21.98	8.97	–0.30	0.77
AP	–16.51	21.75	8.88	–1.86	0.12
POP	–10.11	24.65	10.06	–1.00	0.36
FRC	–1.95	7.07	2.88	–0.67	0.52

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

For Knoop microhardness test, a hardness tester was used (Wolpert Wilson Vickers/Knoop hardness testers -WILSON Instruments-USA). The load of 500 gm was used for porcelain samples and the load of 50 gm was used for composite samples, for all groups the loading time was 30 seconds.

The bleaching procedure was done for each test sample at 37ºC. The top-surface of 14 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 maintained in fresh distilled water at 37ºC till the next bleaching application. The negative controls were stored in distilled water at 37ºC which was changed daily after washing the samples with soft brush under running distilled water for 1 minute to resemble the normal conditions.

After 2 weeks, microhardness tests were done for each sample in a similar manner to baseline 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 enrolled for statistical analysis.

RESULTS

Table 1 presents the mean base line surface microhardness values (Knoop Hardness Number: KHN), and standard deviations for all groups. Group statistics showed that, before bleaching procedure the mean microhardness of the composite specimens was much lower than the ceramics. The differences between the mean hardness of the porcelain samples seem not to be remarkable but the total mean microhardness of the autoglazed specimens was higher than the polished and the overglazed porcelain samples. Tables 2 and 3 present the statistical comparisons of Knoop- microhardness mean values within each group. The microhardness of the control specimens was found to be stable after 2 weeks compared with their baseline quantities, but bleaching with 38% CP affected the microhardness of all the test samples significantly ($p < 0.05$). The most significant change in microhardness occurred in polished porcelain and polished composite samples. The effect of bleaching on surface microhardness of the autoglazed ceramic specimens was less than the overglazed samples; nevertheless even the hardness of autoglazed samples decreased significantly after bleaching process. According to Table 4, the types of surface preparations cause statistically significant differences between the microhardness of the porcelain subgroups ($p < 0.05$).

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

Groups	Mean	SD	SE	t	p	Eff. size Mean diff/SD
OP	6.02	6.06	1.62	3.71	0.00	0.99
AP	6.38	9.49	2.53	2.51	0.02	0.67
POP	61.52	31.47	8.41	7.31	0.00	1.95
FRC	12.12	7.64	2.04	5.93	0.00	1.58

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

DISCUSSION

Interaction between whitening agents and esthetic restorative materials is of critical importance while there is a need for a prolonged contact between bleaching agents and dental structure to allow the oxidation process to happen.[30] The oxidation procedure and low resulting pH has been considered as a potential source of adverse effects.[31] Surface alterations are clinically important properties that merit investigation, since these deleterious impacts can endanger the esthetic and durability of restoration and the long-term health of oral structures.[32]

In this study, the effect of one bleaching agent (CP: 38%) on porcelain material and FRC was evaluated. Porcelain

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	– 5.05	–6.02 ± 6.06	< 0.001	OP *vs* AP (p = 0.000)
AP - baseline	–2.60	–6.38 ± 9.49	<0.001	OP *vs* POP (p = 0.000)
POP - baseline	–60.50	–61.52 ± 31.47	<0.001	AP *vs* POP (p = 0.000)

OP: Overglazed porcelain; AP: Autoglazed porcelain; POP: Polished porcelain; FRC: Fiber reinforced composite specimens were divided in three groups, according to surface treatment. The samples were stored in distilled water, in 37ºC (mouth temperature), during the study period. This was planned according to Hao Yu et al who reported the environmental temperature influences the effect of bleaching on surface microhardness of restorative materials.[33] Campos et al[27] used saliva to simulate oral conditions. It is reported that the substances present in saliva may act as accelerators in degrading CP and may reduce its adverse effects by means of the salivary remineralizing potential.[34] Because the aim of the present study was to examine the effect of the bleaching agents without the parallel effect of other parameters (saliva), distilled water was chosen as storage solution. 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 bleaching studies, where materials were exposed continuously to bleaching products for several days to simulate cumulative effects over a period of time.[15,35,36] The frequency of applying of bleaching agents may contribute to the disparity in results. The wide variations in literature results, regarding microhardness, suggest that some tooth-colored restorative materials may be more susceptible to alternations and some bleaching agents are more likely to cause those alternations.[37] The latter may be attributed to the differences in pH between bleaching agents.[38]

In this study, the bleaching agent decreased the hardness of FRC samples significantly which is in line with the results reported by Hannig,[39] Lima,[40] and Taher.[41] Langsten[42] showed that composite matrices composed of (Bis GMA) could be softened by chemical substances with similar solubility parameter in our study, the urethane dimethacrylate (UDMA) matrices show similar reaction. The hardness of a material is correlated with the resin-filler bonding and also inorganic filler content;[43] therefore it could be supposed that the effect of the bleaching agents on this content could also be the reason for the changes of the microhardness of the restorative materials after bleaching. Chemical softening of composite resins is believed to occur *in vivo*, contributing to wear of the resin in both stress-bearing and non-stress-bearing areas.[44-46]

In our study, we observed that the home bleaching agent reduced the microhardness of porcelain as well. The bleaching effect on polished samples was more noticeable, whereas the glazed specimens (even over or auto glazed) showed less influences. Although, these impacts were significant statistically, the small amount of released SiO_2 content might not be perceptible clinically. It seems that glazed surface decreases the penetration and the influence of agents on ceramic materials. This can be important when frequent adjustment of porcelain in the patient's mouth is needed which removes the glazed surface. Polishing the adjusted area may not be as protective as glaze. Since, all changes were significant, apparently even protective glaze layer cannot preserve the porcelain from all the environmental changes.

With the availability of two types of peroxide in multiple concentrations, the lack of consensus about the effects of bleaching agents on restorative materials among the authors reviewed in this article is not surprising. As the new bleaching agents with various concentrations and application instructions are introduced, their applications are increased due to increased patients' demands. Accordingly, the concerns about their potential adverse effects on dental restorations and patients' general health are also increased. While similar studies and existing controversies will improve the quality and safety of the new materials, dentists should be aware that the physical properties of some dental restorations can be altered by bleaching.[47]

The clinical relevance of the findings exhibited 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 is proven.

Further studies (preferably *in vivo* clinical study) are always entailed since new materials and technologies are introduced to dental profession.

CONCLUSION

The effect of home bleaching agent on the microhardness of the two different esthetic restorative materials can be concluded to:

The total mean microhardness of the AP specimens is higher than the polished and the overglazed samples.

The 38% CP has significant effect on the microhardness of the FRC and the porcelain.

The type of surface preparation significantly affects the amenability of porcelain surface hardness from the bleaching agent.

Polished porcelain is influenced more when compared with glazed specimens, and autoglazed samples show the least hardness reduction.

Clinical implication: Home bleaching agents are easily accessible and their contacts with prevalent esthetic restorations is unavoidable, hence, protecting these restoration from bleaching agents and polishing or reglazing the restorations after bleaching procedure may be useful implications.

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