

Effect of home bleaching on the vickers micro-hardness of resin based dental materials

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Abstract

Introduction: 'Whiter teeth' have become a common cosmetic need for patients and therefore, in an effort to improve the appearance of natural teeth, home whitening agents have gained popularity. This in-vitro study investigates the effect of 6% carbamide peroxide on the Vickers micro-hardness of five aesthetic resin-based restorative materials.

Material and Methods: Eighteen specimens (5x2 mm) for each material including micro-hybrid (Filtek Z250), nanofilled composite (Filtek Z350), packable composite (Quixfil), flowable composite (Surefil SDR), and compomer (Dyract) were fabricated and polished. Afterwards, the specimens were sonicated and stored in distilled water at 37°C for 24 hours. Baseline Vicker's Hardness was recorded. The specimens were then subjected to 14 days bleaching treatment and surface hardness of the composite resins was re-evaluated. Paired t-test and one-way ANOVA with Tukey's post-hoc test ($\alpha = 0.05$) were used for analysis of data.

Results: Surface hardness was significantly reduced for Dyract XP and Surefil SDR, increased for Quixfil and least effected the Filtek Z350 and Filtek Z250 following application of 6% Carbamide peroxide. However, maximum variation in hardness values was observed for Surefil SDR. Statistically similar hardness values were observed among five tested materials except for Surefil SDR before the bleaching procedure, though post-bleaching, substantial difference ($p \leq 0.001$) in the hardness values was detected for most of the tested materials.

Conclusions: Indiscriminate use of home bleaching kits for tooth whitening should be discouraged as it can variably affect the physicochemical properties of existing aesthetic resin based restorations.

Keywords: Bleaching agent; carbamide peroxide; compomer; composite resin; hardness test

Introduction

One of the most challenging tasks associated with increasing aesthetic requirements in dentistry is to yield a restoration that resembles the colour and

form of natural tooth.¹ Recently, composite resins have become the most popular direct restorative material due to their superior aesthetics, minimal tooth reduction and micromechanical bonding to the tooth.² Bleaching is another technique considered to be a minimally invasive cosmetic treatment for discoloured teeth.¹ Home whitening techniques have become the most desired choice for the patient seeking improved dental aesthetics because of its low cost and easy accessibility compared to traditional in-office bleaching techniques.³

Contemporary home tooth whitening kits utilize carbamide peroxide (CP) as an oxidizing agent, resulting in teeth whitening

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by free radical formation. In recent years, tray bleaching with 10% carbamide peroxide has been recommended for patients undergoing orthodontic treatment as an effective tooth whitening procedure without any negative squeal.^{4, 5} However, since the bleaching agent is kept in close contact with the teeth and accompanying restorations, agent can cause undesirable effect on teeth and restorative material.³

Chemical softening, degradation of the restorative material and alteration of physico-mechanical properties such as surface hardness of tooth-coloured restorations after bleaching are probable effects.⁶ However, compared to other tooth-coloured restorations, the organic matrix of resin-based composites makes them more prone to undesirable changes. It has been established that peroxides may lead oxidative hydrolysis of the carbon-carbon bonds of the polymer network resulting in deterioration of the composite restorations.⁷

Controversial data is available regarding the effect of whitening treatments on the surface properties of resin-based materials. Some studies have concluded that at-home bleaching gels can cause softening of composite resins, while others have indicated no significant effect on surface micro-hardness of composite after the application of 15% CP.⁸ Ozduman et.al evaluated the micro-hardness of two different bulk-fil composites using home bleaching agents and observed a significant reduction in top surface hardness values of the material after bleaching.⁶ Al Qahtani also reported a more adverse outcome on the micro-hardness of a nano-filled, silorane-based, and hybrid types of composite materials following application of 10% carbamide peroxide compared to a micro-hybrid.⁹

Li and colleagues used a spectrophotometer to observe remarkable changes in the colour of a packable and nano-hybrid composite resin following bleaching with 15% CP.¹⁰ A similar study showed that the difference was specifically noticeable with a higher

concentration of peroxide applied to low density resins.¹¹ Another study showed that bleaching with different concentrations of peroxide appreciably reduced the surface micro-hardness of micro-filled resin composite.¹² Therefore, it has been recognized that the effect of bleaching depends on the material and that a low concentration of CP will result in minimal changes.¹³

Hence the rationale of the present study was that 'whiter teeth' have become a common aesthetic need for patients, and therefore, in an effort to improve the appearance of natural teeth, home bleaching has gained popularity. However, patients should be informed that the physico-mechanical properties of dental restorations may change after bleaching. This may require polishing or replacement of the bleached restorations. There is no existing study on the influence of 6% carbamide peroxide on micro-hardness of tooth-coloured restorations to the authors' knowledge. It has been hypothesized that the near neutral pH of the 6% carbamide peroxide will allow teeth whitening without affecting the surface hardness of commonly used resin composite materials. Hence the objective was to evaluate the effect of Eco White home bleaching agents (6% carbamide peroxide) on the Vicker's hardness of five aesthetic resins-based restorative materials.

Material and Methods

Five commercially available resin based materials were used (Table I). Sixty composite samples (n=12) were prepared by packing the material in prefabricated Teflon molds (10mm x 2mm), sandwiched between two glass slab. Top and bottom surface of samples were cured with visible light at 4000 mW/cm² irradiance for 60s (Flash Max P4 Ortho, Colorado, USA 1503078). The prepared samples were polished using 1200 grit silicon carbide sheet and automatic polishing machine (Metkon GRIPO 2V Grinder her, Turkey). Afterwards, residue of polishing was removed by sonication and samples were stored in distilled water at 37°C for 24hours.

Prior to bleaching, all samples were air dried using a triple syringe for 60 seconds. Micro-hardness of prepared samples was analysed using Vickers Hardness number (VHN) using WOLPERT Micro-Vickers hardness tester (401MVD, EQPT 0002, SCME, NUST). Each sample was placed on a platform with the diamond indenter facing the surface to be tested. The sample was indented with a load of 200g for 10 sec dwell period at three points and the mean value was recorded.

Afterwards, all samples were subjected to bleaching. The bleach gel was applied to a surface of the sample and left for 5 minutes per day. After each session, the samples were washed for 60 seconds with water spray jet and were stored again in distilled water. To represent clinically relevant bleaching system, bleaching procedure was repeated for 14 days according to the manufacturer's instructions and then the samples were subjected to a hardness testing. Data was analysed using IBM SPSS statistics version 21, Boston, Massachusetts. A paired t-test was used to compare the hardness value before and after bleaching. To determine the difference among the materials, the data was subjected to the analysis of variance (ANOVA) and Tukey's post-hoc test.

Results

Descriptive statistics for each resin based composite material after bleaching are given in Figure 1. Filtek Z350 presented highest micro-hardness values. Bleaching treatment significantly affected the surface hardness of resin based material except for Filtek Z350 (nanocomposite) and Filtek Z250 (microhybrid). Greatest variation in hardness values after 14 days of bleaching were observed for Surefil SDR. Thus, the hypothesis was partially rejected.

Table I: Characteristics of resin-based materials used in the study.

| Material | Composition | Manufacturer | Batch |
|---|---|--------------------|----------------|
| <i>Micro-hybrid composite</i> Filtek™ Z250 XT | Bis-GMA, UDMA, Bis-EMA Zirconia/Silica fillers having particle size 0.01-3.5um Filler loading: 50% | 3M ESPE Filtek™ | N703519 |
| <i>Nano-composite</i> Filtek™ Z350 XT | Bis-GMA, UDMA TEGDMA, PEGDMA, Bis-EMA Combination of 0.004-0.02um non-agglomerated zirconia/silica particles and agglomerated 0.60-1.40 um clusters Filler loading: 57% | 3M ESPE Filtek™ | N660853 |
| <i>Packable composite</i> QuiXfil | Bis-EMA, UDMA, TEGDMA, TMPMA, TCB Strontium glass fractions having particle size 1um-4um. Filler loading: 66% | Dentsply | 15030000 64 |
| <i>Flowable composite</i> Surefil SDR | UDMA, TEGDMA Nano-filled Ba/Si alumino fluorosilicate Filler loading: 45% | Dentsply | 15030006 86 |
| <i>Compomer</i> Dyract® XP | UDMA, TCB Strontium-flouro silicate glass having mean filler size 0.8um Filler loading: 47% | Dentsply | 15020004 26 |

Table II: Comparison of microhardness among the resin based composite materials before bleaching.

| Group | Materials | p value |
|-------------|-------------|--------------|
| Surefil SDR | Dyract XP | 0.024 |
| | Filtak Z250 | 0.621 |
| | Filtek Z350 | 0.001 |
| | QuixFil | 0.076 |

Table III: Comparison of microhardness among the resin based composite materials after 14 days bleaching with 6% carbamide peroxide.

| Group | Materials | p value |
|-------------|-------------|---------|
| Dyract XP | Filtak Z250 | 0.833 |
| | Filtek Z350 | 0.001 |
| | QuixFil | 0.001 |
| | Surefil SDR | 0.001 |
| Filtek Z350 | Dyract XP | 0.000 |
| | Filtak Z250 | 0.000 |
| | QuixFil | 0.816 |
| | Surefil SDR | 0.000 |
| Surefil SDR | Dyract XP | 0.000 |
| | Filtak Z250 | 0.000 |
| | Filtek Z350 | 0.000 |
| | QuixFil | 0.000 |

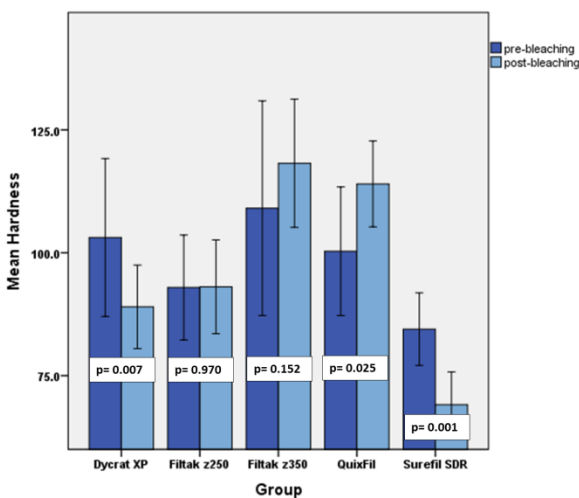


Figure 1: Mean Vickers hardness number and standard deviation of the five tested resin based composite materials before and after 14 days of bleaching with 6% carbamide peroxide.

Inter-group comparison of mean micro-hardness values before bleaching procedure showed statistically similar hardness values among five tested materials except for Surefil SDR (Table II). However, post-bleaching significant difference ($p \leq 0.001$) in the hardness values was observed for most of the tested materials (Table III).

Discussion

At-home bleaching technique for whitening of discoloured teeth has gained popularity among the general population.³ However, since almost half of the population has a restored tooth, the influence of bleaching agents on the new resin-based composites requires attention.¹⁴ Micro-hardness of restorative materials is often correlated with material's strength, resistance to intraoral degradation, stainability and clinical durability.¹⁵ This study identifies the impact of 6% carbamide peroxide used for at-home night guard bleaching on the five popular commercially available composite restorative materials.

Results of the present study showed statistically similar hardness values among five tested materials, with the exception of Surefil SDR. The mechanical properties of dental composites are determined by the interaction of material's composition, degree of polymerization, filler size, particle distribution and filler content.^{16,17} Thus, the low filler content (45%) may have contributed to the low surface hardness of Surefil SDR. In addition, highest micro-hardness values were recorded for Filtek Z350. Hatanaka et al. also observed greater hardness of Filtek Z350 compared to micro-hybrids. The findings were attributed to presences of clusters of zirconia and silica filler particles, which had higher resistance to the Vickers indenter.¹⁸

Significant reductions in the hardness values were observed for Dyract XP and Surefil SDR after bleaching treatment whereas, hardness of QuixFil was significant increased. The trends were aligned with previous studies as different researchers have demonstrated contradictory results after application of 10 to 16% carbamide peroxide, where some studies reported a decreased,¹⁴ or increased¹⁹ or no change in surface hardness of composite. Thus, reflecting the effect of material composition, aging of specimen, phenomenon of continued polymerization and bleaching

protocols on the properties of dental composites.^{3, 14} In a similar study, Ali et al. studied the impact of home and in-office bleaching techniques on the surface roughness of bonded ceramic and resin orthodontic brackets. They reported that brackets subjected to home bleaching had lower roughness values. In addition, resin brackets exhibited highest surface roughness and lower surface stability due to their organic nature which makes them more susceptible to chemical weathering by acidic bleaching agent.²⁰

Quixfil showed a significant increase in surface hardness, which could be attributed to a greater concentration of high molecular weight resins such as Bis EMA and higher filler loading, resulting in fewer double bonds per unit weight. This can lead to a tightly cross-linked polymeric network which resists penetration of the bleaching agent.¹⁹ On contrary, lower filler to resin ratio resulting in greater free-radical induced oxidative cleavage of resin polymeric chains could be responsible for softening effect on Dyract XP and Surefil SDR.¹⁴ Yu et al. observed significant surface softening of composite resin bleached for 14 days with 10% CP at 37°C compared with bleaching performed at room temperature.²¹ Another study demonstrated a significant decrease in hardness values of comonomers after bleaching.²²

Filtek Z350 and Filtek Z250 showed no significant change in surface hardness after bleaching. Zuryati et al and Hatanaka et al reported similar results and these results were probably due to different composition of resin monomers.^{8, 14, 18} Material-based comparison after the bleaching regime showed a significant difference between the surface micro-hardness of resin-based materials. These data suggest that some materials are more susceptible to alteration than others and therefore bleaching agents should be used with caution.¹³

In the present study the influence of saliva was not considered. In this context, these

results may differ from that of the oral cavity. Therefore, in the future, to simulate the clinical situation, bleaching agents can be diluted with saliva. In addition, other mechanical properties of composite resins after application of 6% CP should be investigated. Despite these limitations, results of present study discourage the indiscriminate use of whitening agents in the patient's mouth and also highlight the need to educating patients on the possible outcomes of home bleaching on aesthetic restorations.

Conclusions

Bleaching with 6% carbamide peroxide resulted in significant reductions in the hardness of Dyract XP and Surefil SDR. On contrary microhardness of QuixFil was significantly increased whereas Filtek Z250 and FilteK Z350 had statistically similar hardness values. Hence, indicating that bleaching agent has material dependent effect. Therefore, in order to avoid alteration in physico-mechanical properties of aesthetic restorations, the bleaching agents should be used cautiously.

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