

Original Article

Evaluation of the effects of different concentrations of bleaching agents on flexural strength and microhardness of VITA ENAMIC

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ABSTRACT

Background: Considering the studies on the effects of bleaching materials on properties of dental materials, The aims of this *in vitro* study were to evaluate the effects of two different concentrations of bleaching agents on flexural strength and microhardness of VITA ENAMIC.

Materials and Methods: In this experimental *in vitro* study, 30 rectangular-shaped specimens (2 mm width × 2 mm height × 12 mm length) for flexural strength and 30 specimens (5 mm width × 5 mm length × 2 mm height) for microhardness tests were prepared from VITA ENAMIC blocks 12 × 14 × 18 mm. The specimens were polished using silicon-carbide sandpapers 400, 600, 800, 1200, 2000 under flow of water for 60 s each. The prepared samples for flexural strength and microhardness were divided into 3 subgroups ($n = 10$): control group (C), samples bleached using Opalescence PF 15% (B15), and samples bleached with Opalescence Xtra Boost 40% (B40). Flexural strength measurement was done using a universal testing machine, and microhardness test was done using Vickers. Data were analyzed using analysis of variance and *post hoc* tests and $P < 0.05$ was considered significant.

Results: The mean microhardness values of C, B15, and B40 groups were 255.46 ± 3.02 , 249.86 ± 4.18 , and 235.53 ± 4.61 kgf/mm². Opalescence PF 15% and Opalescence Xtra Boost 40% affected microhardness of ENAMIC significantly ($P < 0.05$). The mean flexural strength values of C, B15, and B40 groups were 155.26 ± 16.13 , 142.14 ± 11.52 , and 133.39 ± 16.13 MPa. A significant decrease in flexural strength was found between the C and B40 groups ($P = 0.007$). However, the difference between flexural strength of the C and B15 groups was not significant ($P > 0.05$).

Conclusion: Our study showed that both concentrations of bleaching agents can affect microhardness of ENAMIC. Moreover, hydrogen peroxide 40% has a negative effect on the flexural strength of ENAMIC.

Key Words: Bleaching agents, flexural strength, hardness, VITA ENAMIC

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INTRODUCTION

Achievement of a healthy, natural, and beautiful smile is one of the most important issues in restorative dentistry.^[1] Besides other techniques, bleaching is a

conservative option to improve the color of stained or darkened teeth.^[2,3] At home and in office bleaching are two common methods of bleaching technique.^[4,5]

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Different materials and concentrations are used for bleaching procedure such as carbamide peroxide and hydrogen peroxide.^[4,6,7]

Effects of bleaching agents on teeth depend on various options such as their concentration, bleaching time, and type of stain.^[6,8] Bleaching procedure works through oxidation-reduction reactions which change the chemical molecular structure of stains and result in tooth whitening.^[9]

Dental ceramics are widely used in restorative dentistry due to their mechanical and esthetic properties.^[6] One of the most important properties of dental ceramics is their chemical survival when exposed to saliva and substances with different pH.^[10] Ceramic restorations can be designed and created in dental laboratories or with the help of computer-aided design/computer-aided manufacturing (CAD/CAM) technology.^[11]

CAD/CAM technology results in materials with higher qualities. Moreover, less amount of time is needed for their creation.^[11,12] Developing new materials for CAD/CAM systems to combine proper characteristics of ceramics such as color stability and durability with improved flexural strength and low abrasiveness of composites has led to production of recent materials like VITA ENAMIC.^[13]

VITA ENAMIC is the first hybrid dental ceramic which has a three-dimensional geometry with two penetration networks. One network is a glass-ceramic material and the other is a polymer (methacrylate) which reinforces the glass-ceramic network.^[11] The two networks have high flexural strength. VITA ENAMIC can absorb mastication forces by balancing between elasticity and flexural strength.^[13] VITA ENAMIC can be used for long-term restorations in the anterior and lateral areas, such as full-coverage crowns, veneers, inlays, and onlays.^[11]

During bleaching procedure, dental ceramics are exposed to bleaching materials. Therefore, their effect on physical and mechanical properties of ceramics has been considerable.^[10]

Every year, various studies are conducted on the effects of bleaching agents on properties of restorative materials. Results of some studies are contradictory.^[10] Culic *et al.* reported that Opalescence PF 15% did not affect surface structure of VITA ENAMIC.^[11] Poludorou *et al.* claimed in a paper that carbamide peroxide 15% did not affect the microhardness of

Vitablocs Mark II ceramic,^[14] while Malkondu *et al.* showed in a research that 20% carbamide peroxide decreased the microhardness of EMPRESS esthetic ceramic.^[11]

Evaluation of different effects of bleaching agents on VITA ENAMIC is important due to desirable properties of VITA ENAMIC and increasing use of this dental material in recent years.^[11]

The purpose of this *in vitro* study was to evaluate the effects of 2 different concentrations of bleaching agents on flexural strength and microhardness of VITA ENAMIC.

MATERIALS AND METHODS

Preparation of samples

In this experimental *in vitro* study, 30 rectangular-shaped specimens 2/2/12 mm¹⁰ for flexural strength test and 30 specimens 5/2/2 mm for microhardness test were prepared from 6 VITA ENAMIC (VITA Zahnfabrik/Germany) blocks 12/14/18 mm. VITA ENAMIC blocks were sectioned using Delta precision sectioning machine (Nemo/Mashhad, Iran) at low speed. The prepared specimens were polished using silicon-carbide sandpapers 400, 600, 800, 1200, 2000 under flow of water for 60 s each.

Bleaching procedure

The prepared samples for flexural strength and microhardness tests were divided into 3 subgroups.

Subgroup (B15)

These specimens were bleached using Opalescence PF 15% (Ultradent/USA) for 14 days, each day 4 h according to the Manufacturer's instructions. During bleaching procedure, specimens were kept in 37°C humid environment in incubator (LTE scientific LTD/Greenfield, Great Britain). Samples were kept in distilled water between bleaching sessions.

Subgroup (B40)

These specimens were bleached using Opalescence Xtra Boost 40% (Ultradent/USA) in 2 sessions 1 week apart, every session 3 times, each time 20 min. Bleaching gel was applied on samples surface. After 20 min, the samples were washed for 30 s. After drying the samples, a new layer of bleaching gel was applied. This procedure was repeated 3 times in each session. Samples were kept in distilled water between bleaching sessions.

Subgroup (C)

Control group samples were kept in distilled water during the procedure and were not bleached.

Flexural strength test

Flexural strength test for all the prepared samples for this test was done using a universal testing machine (koopaa pazhooresh/sari, Iran). Three point bending test was used for measuring flexural strength of prepared samples.

The sample was placed on two supports with the bleaching surface facing the machine's crosshead. There was 10 mm space between the two supports. Crosshead speed was 1.0 mm/min. Loading continued until the sample fractured. Width and height of the sample at the fracture point were measured using digital caliper (Shinwa sokutei/China).

Flexural strength values were calculated using the following equation:^[10]

$$\sigma = \frac{3FL}{2BH^2}$$

Where F is the failure load (in N), L is the distance between the supports (in mm)

B and H are the width and height of fractured points (all in mm).

Microhardness test

Microhardness test for all the prepared samples for this test was done using Vickers (koopaa pazhooresh, sari, Iran). 300 g force was applied to the samples. Loading time was 30 s. Microhardness was measured in 3 points. The calculated average microhardness of these 3 points was reported as the sample's microhardness.

Statistical analysis

The mean microhardness and flexural strength were calculated for all groups. Data were analyzed using SPSS statistical software package SPSS 17.0 for Windows (SPSS, Chicago, Illinois, USA). Data were analyzed using analysis of variance and *post hoc* tests. $P < 0.05$ was considered significant.

RESULTS

Mean Vickers hardness values of VITA ENAMIC and mean flexural strength values are shown in Table 1.

The mean (standard deviation) microhardness values of C, B15, and B40 groups were 255.46 ± 3.02 , 249.86 ± 4.18 , and 235.53 ± 4.61 kgf/mm², respectively.

A statistically significant difference in microhardness between control group and VITA ENAMIC bleached with opalescence pf 15% ($P = 0.011$) and opalescence Xtra Boost 40% ($P < 0.001$) was found.

Furthermore, the difference between microhardness values of VITA ENAMIC bleached with opalescence pf 15% and opalescence Xtra Boost 40% was significant ($P < 0.001$).

The mean (standard deviation) flexural strength values of C, B15, and B40 groups were 155.26 ± 16.13 , 142.14 ± 11.52 , and 133.39 ± 16.13 MPa.

There was a statistically significant difference between the flexural strength values of the control group and VITA ENAMIC bleached with opalescence Xtra Boost 40% ($P = 0.007$).

However, the difference between the control group and VITA ENAMIC bleached with opalescence pf 15% was not significant ($P = 0.135$) as between flexural strength of samples bleached with opalescence pf 15% and opalescence Xtra Boost 40% ($P = 0.394$). Figures 1 and 2 present the mean microhardness and mean flexural strength of VITA ENAMIC.

DISCUSSION

Maintenance of dental restorations that are exposed to saliva and other substances are affected by mechanical properties of restorative materials such as flexural strength and microhardness.^[1] Nowadays, bleaching procedure is a common treatment in dental offices.^[15] While bleaching procedure, bleaching materials may come in contact with dental restorations and crowns in the mouth.^[10] This research was conducted to observe the effects of two different bleaching agents on VITA ENAMIC material.

Table 1: The mean microhardness and flexural strength values of enamic (with standard deviation)

Groups Tests	Control group	Opalescence PF 15%	Opalescence Xtra Boost 40%	P
Microhardness (kgf/mm ²)	255.46±3.02 ^a	249.86±4.18 ^b	235.53±4.61 ^c	<0.001
Flexural Strength (MPa)	155.26±16.13 ^a	142.14±11.52 ^{ab}	133.39±16.13 ^b	<0.001

Different letters (a, b, c) in table represent statistically significant difference in each row

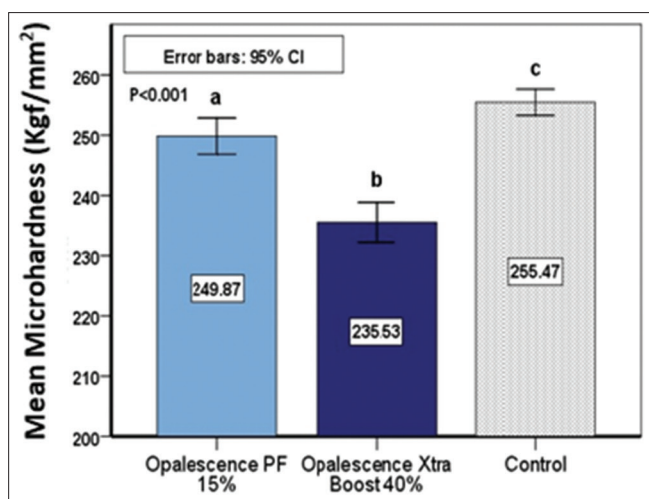


Figure 1: The mean microhardness of VITA ENAMIC (kgf/mm²) different letters (a, b, c) represent statistically significant difference.

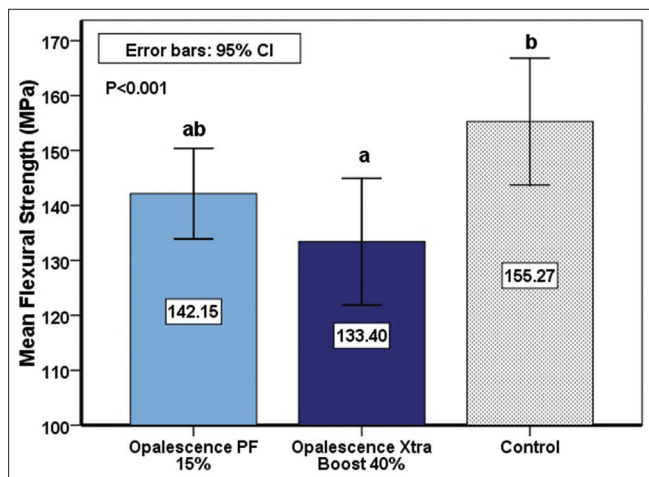


Figure 2: The mean flexural strength of VITA ENAMIC (MPa) different letters (a, b) represent statistically significant difference.

The results of this study showed a significant decrease in microhardness of VITA ENAMIC after bleaching with opalescence pf 15% and Opalescence Xtra Boost 40%.

VITA ENAMIC has two networks which one of these networks is a polymer (methacryl).^[13] In this study, a reduction in microhardness of VITA ENAMIC was expected due to oxidization of resin matrix by the bleaching materials. Some studies reported a decrease in microhardness of methacrylate-based composites after bleaching with carbamide peroxide.^[16,17] Juntavee *et al.* declared in a study that 35% hydrogen peroxide reduces hardness of ENAMIC significantly.^[18] These results are consistent with the results of our study. This microhardness decrease is due to polymer chains cleavage by bleaching gels containing peroxides.^[1]

Carbamide peroxide decomposes into hydrogen peroxide and urea. Hydrogen peroxide breaks into free radicals.^[16] and these free radicals break down polymer chains.^[1] Another factor that reduces the microhardness is increased softening of composite resins due to existence of some monomers. These monomers make composites more susceptible to bleaching gels.^[16] In our study also, the difference between microhardness of bleached specimens was statistically significant and the values were more decreased in specimens bleached with Opalescence Xtra Boost 40%. This explains that bleaching effect on microhardness of VITA ENAMIC is concentration dependent. Malkondu *et al.* suggested that effect of bleaching gels on microhardness of materials is concentration dependent.^[1] This finding is in accordance with our study. This result might be because of the fact that when the concentration gets higher, the penetration depth and dissolution effect of bleaching agent increases and the effect on surface properties becomes higher. Thus, the bleaching agent will have a greater effect on surface properties of dental material.^[1]

Türker and Biskin declared that 10% and 16% carbamide peroxide decreased microhardness of feldspathic porcelain.^[19] A decrease in SiO₂ content in feldspathic porcelain after bleaching affected the surface hardness and decreased the microhardness.^[20] As SiO₂ is one of the important components in VITA ENAMIC,^[21] reduction of SiO₂ content can be another reason for the decrease seen in microhardness of VITA ENAMIC after bleaching.

Furthermore, they are some articles with conflicting results. In Bahannan's research, 10%, 20%, and 35% carbamide peroxide did not affect the microhardness of feldspathic porcelain.^[6] This may be due to different structure of feldspathic porcelain and VITA ENAMIC, different fabrication method, and the fact that VITA ENAMIC is a hybrid ceramic and has a methacryl network.^[11] In another research, Demir *et al.* observed that 16% carbamide peroxide had no significant effect on microhardness of IPS Empress CAD and IPS emax CAD. This conflicting result might be because of different concentrations of bleaching gel used, different ceramics to VITA ENAMIC, and different durations which bleaching gels were used.^[22]

In this study, a statistically significant decrease was found in flexural strength of VITA ENAMIC after bleaching with Opalescence Xtra Boost 40%. However, the decrease in flexural strength of

specimens bleached with Opalescence PF 15% was not significant. Furthermore, there was no statistically significant difference between flexural strength of specimens bleached with Opalescence Xtra Boost 40% and opalescence pf 15%. Flexural strength is especially notable where intense occlusal stresses are applied such as in long-span fixed dental prosthesis.^[23]

It was suggested in a study that 16% carbamide peroxide did not affect the flexural strength of composite resins and it was declared that filler particles, the chemical bondblocks promoted by coupling agents at the interface of resin-filler were some factors that prevented the expansion of cracks in composites during flexural strength test.^[15] This finding is similar to our results. As VITA ENAMIC is a hybrid ceramic,^[11] this can explain why flexural strength of VITA ENAMIC did not change significantly after bleaching with Opalescence PF 15%. In another study, Hao got the same results after bleaching VITA mark II with opalescence pf 15%. Moreover, no changes were observed in flexural strength of this ceramic after bleaching.^[10] Furthermore, there are some studies with contrary results. A study concluded that 15% carbamide peroxide significantly decreased the flexural strength of Z250 micro-hybrid composite resin due to the effect of free radicals of the bleaching agent on the resin section of the material.^[24]

In general, the conflicting results may be due to properties of the studied materials.^[6,22] Moreover, other factors may be concentration of bleaching gels and the period of time that they are applied to the materials.^[16]

According to our study, bleaching agents can affect microhardness of VITA ENAMIC. Moreover, hydrogen peroxide 40% affects the flexural strength of VITA ENAMIC. Hence, the clinicians should prevent the bleaching gel from coming into contact with VITA ENAMIC restorations.

The limitation is that saliva and mastication forces are absent in our study. These factors may affect VITA ENAMICs respond to bleaching gels.^[22] Furthermore, volume loss from VITA ENAMIC surface was not noticed. Further researches can investigate the effects of bleaching gels on the properties of VITA ENAMIC in the presence of saliva and mastication forces in an *in vivo* study. Furthermore, effect of polishing on alternation of VITA ENAMIC's properties after bleaching can be investigated in further studies.

CONCLUSION

1. The microhardness of VITA ENAMIC decreased after bleaching procedure using Opalescence PF 15% or Opalescence Xtra Boost 40%
2. The effects of bleaching materials on microhardness of VITA ENAMIC was concentration dependent
3. The flexural strength of VITA ENAMIC decreased after bleaching with Opalescence Xtra Boost 40%
4. Opalescence PF 15% did not affect flexural strength of VITA ENAMIC
5. No significant differences were observed between flexural strength of VITA ENAMIC bleached with opalescence pf 15% and opalescence Xtra Boost 40%.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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