



Effect of Bleaching with 15% Carbamide Peroxide on Flexural Strength of Three Resin-Based Restorative Materials

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Article Info

Article type:
Original Article

Article History:
Received: 20 Jun 2020
Accepted: 22 Sep 2020
Published: 28 Oct 2020

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ABSTRACT

Objectives: Considering the increasing use of vital bleaching procedures and the increased application of newly introduced resin-based materials for tooth restoration, this study was designed to evaluate the effect of 15% carbamide peroxide gel on the flexural strength of three resin-based restorative materials.

Materials and Methods: Three different types of restorative materials namely Beautifil II giomer, Cention N, and Z250 micro-hybrid composite resin were evaluated in this in vitro, experimental study. Twenty-four bar-shaped specimens were prepared from each restorative material, totaling 72 specimens, and were randomly assigned to two subgroups with and without bleaching procedure (n=12). In the bleaching subgroups, 15% carbamide peroxide gel was applied on the specimen surface 8 h a day for 14 days. The flexural strength of the specimens was then measured. Two-way ANOVA was used to compare the flexural strength of the specimens.

Results: There was a significant reduction in the flexural strength of materials following exposure to the bleaching agent ($P < 0.05$). The flexural strength was significantly higher in the groups that did not undergo bleaching. However, the mean flexural strength of the restorative materials was not significantly different ($P = 0.12$).

Conclusion: The flexural strength of Beautifil II giomer, Cention N, and Z250 micro-hybrid composite resin could be compromised subsequent to bleaching with 15% carbamide peroxide gel. The three resin-based restorative materials exhibited similar flexural strength values irrespective of the use or no use of 15% carbamide peroxide gel.

Keywords: Composite Resins; Dental Restoration; Permanent; Flexural Strength; Tooth Bleaching

- **Cite this article as:** Kimyai S, Ghavami Lahij Y, Daneshpooy M, Jafari Navimipour E, Alizadeh Oskoe P. Effect of Bleaching with 15% Carbamide Peroxide on Flexural Strength of Three Resin-Based Restorative Materials. *Front Dent.* 2020;17: 27. 10.18502/fid.v17i27.4651

INTRODUCTION

Currently, vital tooth bleaching procedures are one of the most popular esthetic procedures in dentistry due to their rapid and favorable outcomes and safety [1]. Various materials and techniques are available for

vital bleaching procedures, which can be carried out in the office, at home, or a combination of both [2]. At-home tooth bleaching technique is a popular treatment modality among both patients and dentists due to its excellent clinical efficacy, low cost,

and safety [3]. Generally, this treatment relies on the use of hydrogen peroxide or carbamide peroxide. In this technique, unstable free radicals released through the disintegration of peroxide react with pigments or large pigmented molecules, oxidizing these organic compounds in the tooth structure, which results in a change in the wavelength of the light beams reflected from the tooth structure. This ultimately makes the tooth appear lighter in color [2,4].

Since the bleaching agents in the oral cavity might contact the existing restorations, the possible effects of bleaching agents on the restorative materials has been an interesting research topic [5]. Reports indicate that the bleaching agents can change the properties of restorative materials such as their color, surface microhardness, surface roughness, and flexural strength [3,5], through changes in their chemical composition and morphological structure [6]. The flexural strength is one of the mechanical properties of restorative materials, which might be related to their clinical performance. The results of flexural strength tests might, to some extent, predict the behavior of restorative materials under stresses resulting from the functional or parafunctional forces [7]. Materials with low flexural strength undergo deformation under strong masticatory forces, resulting in deterioration of the marginal seal of restorations bonded to the tooth structure [6]. Some studies have evaluated the flexural strength of restorative materials after bleaching with bleaching agents and have reported contradictory results, including a reduction, no change, or increase in the flexural strength of these materials [3,5-9]. The discrepancies between the results of different studies might be attributed to differences in the bleaching agents, their concentrations and pH, the bleaching protocol and its duration, the restorative materials evaluated with different compositions, and the ambient temperatures [5,8,9].

Giomers are a new group of composite materials composed of pre-reacted glass-ionomer fillers in a resin matrix; they have some advantages, including the release of

fluoride ions and recharging, similar to glass-ionomers, in conjunction with other properties of composite resins, such as optimal esthetics, polishability, and tissue compatibility [10,11]. A study reported that the use of 15% carbamide peroxide increased the surface roughness of giomer, with no change in its color [12]. Another study showed that the use of 40% hydrogen peroxide increased the color change of giomer and decreased its translucency [13]. Kimyai et al. [14] revealed that the use of 15% and 45% carbamide peroxide significantly decreased the microhardness of giomer. Recently, a new resin-based material was marketed, referred to as Cention N. It is a tooth-colored restorative material and has been recommended for direct restorations. It is self-cured, but can selectively undergo a light-curing process. Cention N has been classified as an alkasit material and contains alkaline fillers within a methacrylate resin matrix [15]. An in vitro study showed that this material could prevent caries at the restoration margins in class V cavities by releasing calcium and fluoride ions [16]. It has been reported that the flexural strength of Cention N is comparable to that of nano-hybrid and micro-hybrid composite resins [15].

On the other hand, 10%-16% carbamide peroxide is one of the most commonly used materials for at-home bleaching procedures [3,14]. Since the effect of bleaching agents on the mechanical properties of restorative materials depends on the type of restorative material [5], and since no study, to date, has evaluated the effect of carbamide peroxide bleaching agent on the flexural strength of giomer and Cention N, the present in vitro study was designed to evaluate the effect of 15% carbamide peroxide on the flexural strength of giomer and Cention N in comparison with Z250 micro-hybrid composite resin.

MATERIALS AND METHODS

The present in vitro study was carried out on 24 bar-shaped specimens (measuring 25 mm in length, 2 mm in width, and 2 mm in height) [9] fabricated from the A2 shade of giomer

(Beautiful II; Shofu Dental Corporation, Osaka, Japan), Cention N (Ivoclar Vivadent AG, Schaan, Liechtenstein) and Filtek Z250 (3M ESPE Dental Products, St Paul, MN, USA) restorative materials. The total number of specimens was 72. The regional ethics committee approved the protocol of the present study (Ref. No. IR. TBZMED. VCR. REC. 1398.037). The sample size was determined to be 11 in each group based on the results of a pilot study on five specimens in each group and also based on the results of two-way ANOVA considering $\alpha=0.05$, study power of 80%, and a difference of 8 units in the mean flexural strength values. However, to increase the validity of the results, 12 specimens were included in each group (a total of 72 specimens).

A silicon mold was used to prepare the specimens according to the manufacturers' instructions. The test materials were applied into the molds with a spatula and packed with a condenser. A transparent matrix band (Hawe Neos Dental, Bioggio, Switzerland) was placed on each mold and pressed with a glass slab to achieve a smooth and homogeneous surface. The specimens underwent light curing procedure for 40 s, using a light-curing unit (Dentamerica, San Jose, CA, USA) with a light intensity of 400 mW/cm². The tip of the curing unit was positioned close to the surface at a right angle (at 90°). It should be pointed out that in the present study, the dual-cure polymerization mode was selected for Cention N. The specimens were retrieved from the molds, light-cured again for 20 s from each side for complete polymerization, and incubated in distilled water at 37°C for 24 hours. Next, the specimen surfaces were polished with medium, fine and superfine polishing discs (Sof-Lex; 3M ESPE Dental Products, St Paul, MN, USA). The polished specimens were placed in an ultrasonic bath containing distilled water for 1 min for cleaning [5]. Finally, the specimens were incubated in distilled water at 37°C for one week for optimal polymerization [17].

The specimens made from each restorative material were randomly assigned to two subgroups (n=12) with and without the

bleaching procedure. In the non-bleaching subgroups, the specimens did not undergo bleaching and were stored in distilled water at 37°C for 14 days [14]. In the bleaching subgroups, the specimens underwent a bleaching procedure with 15% carbamide peroxide gel (Opalescence® PF; Ultradent Products, South Jordan, UT, USA) for 8 h a day for 14 days [14]. Adequate amount of the bleaching agent was applied on the whole surface of the specimens. The specimens were rinsed with distilled water and incubated in distilled water at 37°C after each bleaching process, until the next bleaching procedure. Distilled water was refreshed daily. The specimens were positioned on the supports of a universal testing machine (Hounsfield Test Equipment Model HSK-S; Salfords, Redhill, Surrey, England) for the flexural strength test. The strain was applied at a rate of 1 mm/min until the fracture of specimens. The flexural strength value (σ) was calculated in megapascals (MPa) using the formula below [5]:

$\sigma=3FL/2BH^2$ where F is the fracture force in Newtons, L is the distance between the supports in millimeters (20 mm in this study), B is the sample width in millimeters, and H is the sample height also in millimeters [5].

The data were analyzed using SPSS version 16 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to evaluate the normality of the data. Two-way ANOVA was used to evaluate the effects of type of resin-based restorative material and exposure to the bleaching agent on flexural strength. Statistical significance was set at $P<0.05$.

RESULTS

Table 1 presents the descriptive statistics of the flexural strength, and the results of statistical comparisons between the study groups and subgroups. Figure 1 shows the error bar of the mean flexural strength values of the study groups and subgroups.

The results of two-way ANOVA showed a significant difference in the mean flexural strength values between the bleaching and non-bleaching subgroups ($F_{1,66}=103.93$, $P<0.001$).

Table 1. Mean and standard deviation of flexural strength (megapascals) of all study groups

Restorative material	Without bleaching	With bleaching*
Z250 composite resin	91.89±11.20	69.04±10.05
Cention N	89.93±9.00	69.92±10.21
Beautiful II giomer	87.31±7.46	63.45±6.80

*P<0.001 between bleached and non-bleached specimens in all groups

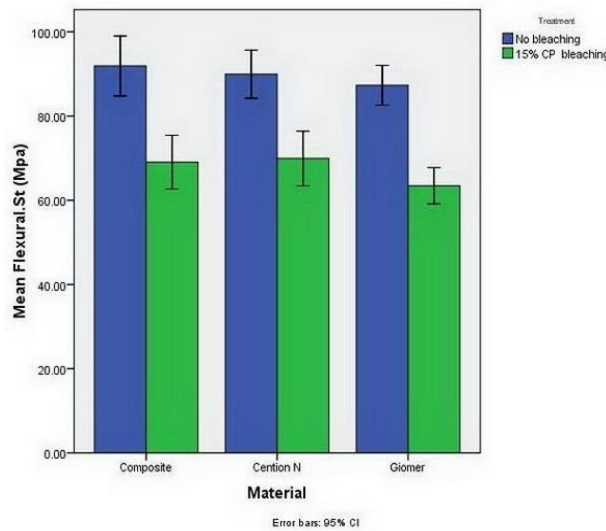


Fig. 1. Error-bar of the mean flexural strength of the study groups and subgroups

The bleached subgroups showed significantly lower flexural strength values than the non-bleached subgroups. However, the mean flexural strength of different restorative materials was not significantly different ($F_{2,66}=2.18$, $P=0.12$). The interaction effect of type of restorative material and exposure to the bleaching agent on flexural strength of the materials was not significant either ($F_{2,66}=0.27$, $P=0.75$).

DISCUSSION

Despite the increase in demand for tooth bleaching procedures and the optimal efficacy of this treatment modality for lightening of tooth color, the effect of different bleaching techniques on all the properties of restorative materials has not been completely elucidated [8].

In the present study, a three-point bending test was performed to determine the flexural strength of the materials. Various simultaneous and dynamic stresses exerted on teeth during masticatory function are evaluated by the flexural strength test [7]. According to previous studies, the three-point bending test is associated with lower standard deviation and variation coefficients and less complex distribution of cracks in composite resins than the biaxial bending test [18,6]. In the current study, 15% carbamide peroxide gel was used 8 h a day for 2 weeks to mimic the home bleaching technique [19]. The results of this study showed that bleaching with 15% carbamide peroxide significantly decreased the flexural strength of giomer, micro-hybrid composite resin, and Cention N restorative materials. Meanwhile, the results of a study by Yu et al. [8] indicated that bleaching with 40% hydrogen peroxide significantly decreased the flexural strength of compomer. Firoozmand et al. [7] reported that bleaching with 35% hydrogen peroxide significantly decreased the flexural strength of composite resin, compomer, and resin-modified glass-ionomer. Yu et al. [5] showed that bleaching with 10% carbamide peroxide significantly decreased the flexural strength of compomer and glass-ionomer.

Reduction in flexural strength after the bleaching procedures might be attributed to the effect of free radicals of the bleaching agents on the resin portion of the tested restorative materials. It has been demonstrated that free radicals are responsible for the oxidation of unprotected double bonds in the resin structure in both the polymer network and at the resin-filler interface [9]. Induction of the oxidative cleavage of polymer chains [5], chemical softening of the resin matrix, a decrease in the microhardness of restorative materials [14,20,21], gap formation [6], and porosities on the surface of restorative materials [22] have been reported after bleaching. The effects of oxidizing agents present in the bleaching agents on the resin matrix, followed by water sorption in association with complete or partial debonding of fillers, have

been reported as reasons for a decrease in the microhardness of resin-based materials after the bleaching procedures [19]. Yu et al. [5] attributed the decrease in the flexural strength of restorative materials after bleaching to the softening and reduction in the hardness of materials.

According to the manufacturer's brochure, the resin components in Z250 composite resin consist of bisphenol A-glycidyl methacrylate (Bis-GMA), urethane dimethacrylate (UDMA) and bisphenol A-ethoxylate dimethacrylate (Bis-EMA). These components in giomer are Bis-GMA and triethylene glycol dimethacrylate. The resin structure of Cention N is devoid of Bis-GMA and consists of UDMA and low-viscosity dimethacrylates [15]. It has been reported that Bis-GMA copolymer is more susceptible to degradation and softening by the bleaching agents compared with UDMA [6,20]. Considering the absence of Bis-GMA in Cention N, it probably has a higher rate of dissolution of surface particles; however, further studies are still required on this topic. Contrary to the results of the present study, two previous studies showed that bleaching with 10% carbamide peroxide and 40% hydrogen peroxide did not significantly change the flexural strength of ceramics and nano-hybrid, packable, micro-hybrid and flowable composite resins [5,8]. The differences in the dimensions of the specimens might explain the differences in the results of studies. In the present study, the specimens measured 25 mm in length, according to ISO 4049 [9]. Some researchers have reported that the dimensions of the specimens specified for measuring the flexural strength by the ISO 4049 ($25 \times 2 \times 2 \text{ mm}^3$) are not clinically realistic, and it is not possible to prepare such specimens without any flaws. Therefore, the size of specimens in their studies were smaller ($12 \times 2 \times 2 \text{ mm}^3$) [5,8]. Another reason for the differences in the results might be the use of restorative materials with different compositions. It has been reported that the effect of bleaching procedures on the restorative materials is material-dependent, and materials with different monomer systems might exhibit different rates of

susceptibility to bleaching agents [8]. In addition, the silane-mediated bond between the filler and resin, the conversion rate of the resin matrix, and the filler content can affect the mechanical properties of the materials [3]. A study showed that 16% carbamide peroxide did not affect the flexural strength of four different types of composite resins (Filtek Z100, Filtek Z350, Brilliant and Opallis) [3]. The differences in the dimensions of specimens and the high filler content of Filtek Z100 (71% of the volume) compared with other materials might explain the differences in the results. A high filler content increases the material's hardness [3]. It appears that high filler content increases the resistance to bleaching agents and softening resulting from the bleaching procedures. Differences in the methodology of studies and the duration of bleaching procedure might give rise to differences in the results [8]. In the study by Yu et al, [8] the flexural strength of Filtek Z250 micro-hybrid composite resin was not significantly affected despite the use of a high concentration of hydrogen peroxide (40%) [8]. However, the use of 15% carbamide peroxide in the present study significantly decreased the flexural strength of Z250 composite resin. It appears that the difference in the results of these two studies can be explained by the shorter duration of the bleaching procedure (a total of 80 min) in their study. Although higher concentrations of the bleaching agents are used for the in-office bleaching procedures, the detrimental effect of these procedures on the restorative procedures might be similar or even less than that of home bleaching procedures which require longer durations of exposure [8]. A study showed that bleaching with 16% carbamide peroxide (4 h a day for 2 weeks) did not affect the diametral tensile strength of Z250 composite resin, and it was reported that the effect of carbamide peroxide was confined to the material's surface, resulting in only a decrease in the microhardness of material [20]. The reason for the difference between the results of these two studies might be the evaluation of the diametral tensile strength instead of the flexural strength and the shorter

duration of the bleaching procedure. Evidence shows that the bleaching agents are more reactive at higher ambient temperatures and penetrate into deeper layers of restorative materials to exert greater effects on the mechanical properties of these materials [5]. In the present study, the laboratory procedures were carried out at 37°C, which might be a reason for the significant effect of 15% carbamide peroxide on the flexural strength of materials. In this context, another study showed that bleaching with 10% carbamide peroxide at 37°C resulted in surface roughening of four different types of composite resins (Filtek Flow, Filtek Z250, Filtek Z350 and Filtek P60), compomer and conventional glass-ionomer; while at 25°C, surface softening was observed only in compomer and the conventional glass-ionomer [17]. Another finding of the present study, irrespective of the conduction of bleaching procedure, was the absence of a significant difference in the flexural strength between the three resin-based materials, which might be due to an almost similar filler content of these materials. According to the manufacturers' brochures, the filler content of Filtek Z250, giomer and Cention N is 60%, 68.6% and 57.6%, respectively. It has been demonstrated that the inorganic filler content is directly correlated with the mechanical properties of restorative materials [23]. A study showed that the flexural strength of Cention N is similar to that of micro-hybrid and nano-hybrid composite resins [15]. Long-term studies are recommended to evaluate the effect of bleaching agents with different compositions, concentrations and pH values under conditions similar to those of the oral cavity on flexural strength of different restorative materials. Considering the results of the present study, it appears that dentists should be aware of the possibility of some changes in the properties of restorative materials after bleaching procedures. Furthermore, they should inform their patients that the existing restorations might require polishing or even replacement after the bleaching procedures.

CONCLUSION

Under the limitations of the present study, it was concluded that 15% carbamide peroxide gel decreased the flexural strength of a micro-hybrid composite resin, giomer and Cention N. There was no significant difference in the flexural strength of resin-based restorative materials, irrespective of the conduction of bleaching procedure.

ACKNOWLEDGMENTS

The authors extend their gratitude to the Vice Chancellor for Research at Tabriz University of Medical Sciences for their financial support. Furthermore, the authors would like to thank Dr. Majid Abdolrahimi (D.D.S.), who edited the English manuscript of this article.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Pimentel de Oliveira R, Baia JCP, Ribeiro MES, Junior MHDSES, Loretto SC. Influence of time intervals between bleaching procedures on enamel microhardness and surface roughness. *Open Dent J*. 2018 Jul;12:555-9.
2. Ranjbar Omrani L, Khoshamad S, Tabatabaei Ghomshe E, Chiniforush N, Hashemi Kamangar SS. In vitro effect of bleaching with 810 nm and 980 nm diode laser on microhardness of self-cure and light-cure glass ionomer cements. *J Lasers Med Sci*. 2017 Fall;8(4):191-6.
3. Hatanaka GR, Abi-Rached Fde O, Almeida-Júnior AA, Cruz CA. Effect of carbamide peroxide bleaching gel on composite resin flexural strength and microhardness. *Braz Dent J*. 2013;24(3):263-6.
4. Peixoto AC, Vaez SC, Pereira NAR, Santana CNDS, Soares KDA, Romão ACTR, et al. High-concentration carbamide peroxide can reduce the sensitivity caused by in-office tooth bleaching: a single-blinded randomized controlled trial. *J Appl Oral Sci*. 2018 May;26:20170573.
5. Yu H, Li Q, Lin Y, Buchalla W, Wang Y. Influence of carbamide peroxide on the flexural strength of tooth-colored restorative materials: an in vitro study at different environmental temperatures. *Oper Dent*. 2010 May-Jun;35(3):300-7.
6. Feiz A, Samanian N, Davoudi A, Badrian H. Effect of different bleaching regimens on the

- flexural strength of hybrid composite resin. *J Conserv Dent*. 2016 Mar-Apr;19(2):157-60.
7. Firoozmand LM, Pagani C. Influence of bleaching treatment on flexural resistance of hybrid materials. *Acta Odontol Latinoam*. 2009;22(2):75-80.
 8. Yu H, Zhang CY, Wang YN, Cheng H. Hydrogen peroxide bleaching induces changes in the physical properties of dental restorative materials: Effects of study protocols. *J Esthet Restor Dent*. 2018 Mar;30(2):52-60.
 9. Geramipanah F, Rezaei SM, Jafary M, Sadighpour L. Comparison of flexural strength of resin cements after storing in different media and bleaching agents. *Eur J Prosthodont Restor Dent*. 2015 Jun;23(2):56-61.
 10. Kimyai S, Pournaghi-Azar F, Mohammadi N, Babri M. Effect of hemostatic agent on marginal gaps of class V giomer restorations. *J Clin Exp Dent*. 2017 May;9(5):672-6.
 11. Arami S, Kimyai S, Oskoe PA, Daneshpooy M, Rikhtegaran S, Bahari M, et al. Reparability of giomer using different mechanical surface treatments. *J Clin Exp Dent*. 2017 Apr;9(4):520-6.
 12. Mohammadi N, Kimyai S, Abed-Kahnamoii M, Ebrahimi-Chaharom ME, Sadr A, Daneshi M. Effect of 15% carbamide peroxide bleaching gel on color stability of giomer and microfilled composite resin: an in vitro comparison. *Med Oral Patol Oral Cir Bucal*. 2012 Nov;17(6):1082-8.
 13. ElSayed II. Color and translucency of finished and unfinished esthetic restorative materials after staining and bleaching. *Saudi Dent J*. 2018 Jul;30(3):219-25.
 14. Kimyai S, Bahari M, Naser-Alavi F, Behboodi S. Effect of two different tooth bleaching techniques on microhardness of giomer. *J Clin Exp Dent*. 2017 Feb;9(2):249-53.
 15. Ilie N. Comparative effect of self- or dual-curing on polymerization kinetics and mechanical properties in a novel, dental-resin-based composite with alkaline filler. *Materials (Basel)*. 2018 Jan;11(1).
 16. Donly KJ, Liu JA. Dentin and enamel demineralization inhibition at restoration margins of Vitremer, Z 100 and Cention N. *Am J Dent*. 2018 Jun;31(3):166-8.
 17. Yu H, Li Q, Cheng H, Wang Y. The effects of temperature and bleaching gels on the properties of tooth-colored restorative materials. *J Prosthet Dent*. 2011 Feb;105(2):100-7.
 18. Chung SM, Yap AU, Chandra SP, Lim CT. Flexural strength of dental composite restoratives: comparison of biaxial and three-point bending test. *J Biomed Mater Res B Appl Biomater*. 2004 Nov;71(2):278-83.
 19. Attin T, Hannig C, Wiegand A, Attin R. Effect of bleaching on restorative materials and restorations--a systematic review. *Dent Mater*. 2004 Nov;20(9):852-61.
 20. Lima DA, De Alexandre RS, Martins AC, Aguiar FH, Ambrosano GM, Lovadino JR. Effect of curing lights and bleaching agents on physical properties of a hybrid composite resin. *J Esthet Restor Dent*. 2008;20(4):266-73.
 21. Campos I, Briso AL, Pimenta LA, Ambrosano G. Effects of bleaching with carbamide peroxide gels on microhardness of restoration materials. *J Esthet Restor Dent*. 2003;15(3):175-82.
 22. Turker SB, Biskin T. Effect of three bleaching agents on the surface properties of three different esthetic restorative materials. *J Prosthet Dent*. 2003 May;89(5):466-73.
 23. Ilie N, Hickel R. Investigations on mechanical behavior of dental composites. *Clin Oral Investig*. 2009 Dec;13(4):427-38.