International Journal of Dental Research and Allied Sciences
2024, Volume 4, Issue 1, Page No: 16-22

Available online at: www.tsdp.net

ISSN: 3062-3502

Original Article

An In Vitro Investigation of Home Bleaching and Its Impact on the Surface Texture of Dental Cosmetic Biomaterials

Samar Hatem Abuzinadah[1]*

[1]Department of Restorative Dentistry, King Abdul-Aziz University, Faculty of Dentistry, Jeddah, Saudi Arabia.

***E-mail** ✉ sabuzinadah1@kau.edu.sa

Received: 04 December 2023; **Revised:** 06 March 2024; **Accepted:** 07 March 2024

ABSTRACT

When planning a whitening or bleaching procedure, it is essential to use either indirect or direct tooth-colored restorative materials that closely match the natural tooth shade. This study aimed to investigate the effects of home bleaching agents on the surface texture of these materials, specifically focusing on restorative dental biomaterials. Two types of commercially available resin composites, packable and flowable, were selected as the tooth-colored materials under investigation. A total of 40 specimens were prepared following standard protocols to evaluate the effect of different concentrations of bleaching agents on surface roughness before and after treatment. A statistically significant increase in surface roughness was observed, with values increasing from 7.18 ± 4.62 to 101.30 ± 11.32 after the use of bleaching agents. However, no significant difference was found between the roughness of packable and flowable composites. Similarly, variations in bleaching agent concentration did not produce a statistically significant effect. The findings indicate that bleaching agents contribute to the degradation of tooth-colored restorative materials, leading to increased surface roughness after treatment compared to baseline levels. The flowable composites showed a similar susceptibility to bleaching effects as the packable composites. Regardless of concentration, both tested bleaching agents caused comparable increases in surface roughness in the resin-based composites.

Keywords: Flowable composites, Dental biomaterial, Resin-based composite, Bleaching agents, Packable composite

How to Cite This Article: Abuzinadah SH. An In Vitro Investigation of Home Bleaching and Its Impact on the Surface Texture of Dental Cosmetic Biomaterials. Int J Dent Res Allied Sci. 2024;4(1):16-22. https://doi.org/10.51847/uzY8DPehMS

Introduction

The growing popularity of teeth whitening as a solution for discoloration has made it an integral part of modern dental treatments. Home-based whitening agents, when used with proper precautions, offer a convenient, cost-effective alternative that reduces the need for frequent dental visits and carries fewer risks compared to in-office procedures [1, 2]. However, the continuous use of these bleaching products, particularly those with higher chemical concentrations, poses a challenge for practitioners in determining the most suitable treatment approach. In professional settings, customized trays containing 6% hydrogen peroxide (HP) or 16% carbamide peroxide (CP) are commonly used for both in-office and at-home applications [3].

Prolonged use of bleaching agents leads to increased surface roughness and reduced indentation hardness, which are primary concerns in dental treatments. A rough tooth surface creates an ideal environment for food particles and oral flora to accumulate. The adhesion of oral microorganisms facilitates biofilm formation, while trapped food particles provide a nutrient-rich setting for microbial growth. For this reason, assessing the texture and quality of tooth-colored restorative materials is essential [4-6].

Studies have reported conflicting findings regarding the effects of bleaching agents on surface roughness [7]. Resin-based dental composites are preferred over amalgam restorations due to their strong adhesion to enamel, a property that amalgam lacks. Additionally, concerns regarding the health risks associated with amalgam, particularly due to its mercury content, cannot be overlooked [8]. However, research suggests that the durability and performance of resin composites depend on factors such as resin formulation, bleaching gel composition, and exposure conditions [7, 9, 10].

Resin-based dental composites are widely used in esthetic zones due to their ability to replicate natural tooth color. However, maintaining their mechanical and morphological properties remains a challenge. Mechanical characteristics significantly influence the longevity and clinical performance of resin restorations [11]. The quality of these restorations is closely tied to surface texture, which is affected by several factors, including filler type, filler size, monomer composition, and its overall percentage in the material [12, 13].

Inadequate surface texture can lead to food accumulation and biofilm development, increasing the likelihood of periodontal disease, opportunistic oral infections, and dental caries progression [6, 14]. To achieve a smooth resin-based restoration, many researchers shape the material against a matrix band. However, surface texture can be modified during the restoration process through routine activities such as tooth brushing or exposure to bleaching agents. Research suggests that nano-filled resin-based composites are the preferred choice for restorations when whitening or bleaching treatments are planned [15]. Based on this, the present study proposed that the surface properties of packable and flowable resin composites would remain unchanged following the application of a home bleaching agent.

Materials and Methods

Collection of resin composites and beaching agents

In this study, two commercially available resin composites were utilized: CHARISMA Diamond nano-hybrid and CHARISMA FLOW, both from KULZER, Germany. For the comparative analysis of the composites, two home bleaching agents were employed: Opalescence 35% and Fläsh 16%, both containing Carbamide Peroxide.

Construction of disc specimens

Approximately 40 disc-shaped specimens were created using a split mold, each measuring five mm in diameter and three mm in thickness. The specimens were then evenly divided into two groups: 20 discs of packable composite and 20 discs of flowable composite. The resin composites were modified according to the provided instructions, followed by packing and curing. After molding the resin composite, a mylar strip was placed, and a thin glass slide was positioned on top of the mold. A 100 gm weight was applied to ensure consistent pressure, allowing the material to make direct contact with the curing tip of the slide. Once curing was completed, the mold was removed to obtain the composite discs **(Figure 1)**.

Figure 1. Construction of disc specimens

Surface texture analyses

Each disc sample was assigned a unique number to maintain identification for surface texture analysis. The baseline surface roughness (Ra) of each specimen was measured using a digital optical roughness tester (Bruker Company, USA). The discs were then exposed to the bleaching agent for the duration specified in the instructions, after which they were removed from the bleaching gel. Following this, all specimens underwent a washing procedure, dried, and the surface texture was re-assessed using the digital optical roughness tester. The equipment used during the experiment is depicted in **Figure 2**.

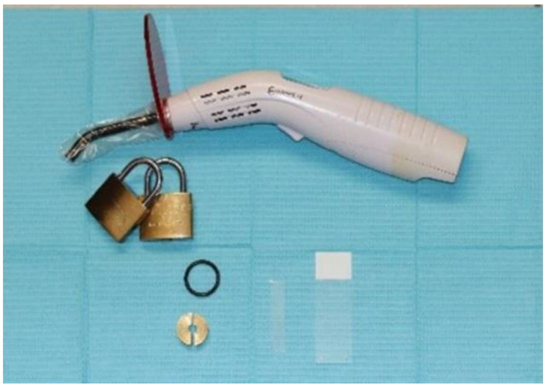

Figure 2. The armamentarium used throughout the experimentation.

Statistical analyses

The data were collected and organized for analysis using SPSS (Statistical Package for the Social Sciences) software. Normality and homoscedasticity assumptions were satisfied, and sphericity was not applicable due to only 2 repeated measurements. No outliers were found. A mixed-model repeated measures analysis of variance (ANOVA) was used, with 1 within-subject factor and 2 between-subject factors, to evaluate if significant differences existed in Ra values before and after treatment, based on the type of resin and bleaching agent.

Results and Discussion

The means and standard deviations for both groups are summarized in **(Table 1)**. A repeated measures mixed model ANOVA, along with post hoc testing, was applied for analysis. The significance threshold was set at an alpha level of .05. The main effect of resin showed no significant differences, F(1, 36) = 0.00, P = .977, indicating similar Ra values before and after treatment within each resin type. In contrast, the bleaching agent's effect was important, F(1, 36) = 4.40, P = .043, pointing to notable changes in Ra before and after treatment depending on the bleaching agent used. However, the interaction between resin and bleaching agent did not reach significance, F(1, 36) = 0.58, P = .452, meaning no combined effect of resin type and bleaching agent on Ra was observed. The within-subjects factor showed a significant effect, F(1, 36) = 2,601.38, P < .001, confirming a significant difference in Ra values before and after treatment overall. The interaction between within-subjects and resin did not produce significant results, F(1, 36) = 0.03, P = .873, indicating a consistent pattern for Ra changes across resin types. Similarly, the interaction between within-subjects and bleaching agents wasn't significant, F(1, 36) = 0.17, P = .680, meaning the relationship between Ra before and after was stable across bleaching agents. Lastly, the interaction effect between within-subjects, resin, and bleaching agent did not reveal significance, F(1, 36) = 1.79, P = .189, demonstrating no combined effect of all factors on Ra. The results of the ANOVA are displayed in **(Table 2)**.

Table 1. Mean and standard deviation for Ra before and Ra after the application of tested bleaching agents

				Ra before		**Ra after**	
				Mean	**SD**	**Mean**	**SD**
Composite resin	Packable resin composite	Bleaching agent	35% CP bleaching agent	5.14	2.49	100.70	10.08
			16% CP bleaching agent	9.50	5.91	101.65	7.77
			Total	7.32	4.95	101.18	8.78
	Flowable resin composite	Bleaching agent	35% CP bleaching agent	5.90	5.28	96.96	16.81
			16% CP bleaching agent	8.18	3.12	105.87	8.12
			Total	7.04	4.38	101.42	13.64
	Total	Bleaching agent	35% CP bleaching agent	5.52	4.04	98.83	13.63
			16% CP bleaching agent	8.84	4.65	103.76	8.03
			Total	7.18	4.62	101.30	11.32

Ra = rough average mean, SD = standard deviation bold value indicates statistical significance, and CP = carbamide peroxide.

Table 2. Mixed model ANOVA results

Source	**df**	**SS**	**MS**	**F**	**p**	$\eta_{p}2$
Between-subjects						
Resin	1	0.07	0.07	0.00	.977	0.00002
Bleaching agent	1	346.43	346.43	4.40	.043	0.11
Resin: Bleaching agent	1	45.51	45.51	0.58	.452	0.02
Residuals	36	2,837.18	78.81			
Within-subjects						
Within factor	1	177,308.55	177,308.55	2,601.38	< .001	0.99
Resin: Within factor	1	1.76	1.76	0.03	.873	0.0007
Bleaching agent: Within factor	1	11.78	11.78	0.17	.680	0.005
Resin: Bleaching agent: Within factor	1	122.13	122.13	1.79	.189	0.05

Residuals	36	2,453.74	68.16

Post-hoc

The mean differences were analyzed using Tukey's post-hoc comparisons, with a significance level set at .05. These comparisons were performed to assess the variations in the estimated marginal means for each combination of between-subject and within-subject effects, as illustrated in **Figure 3**.

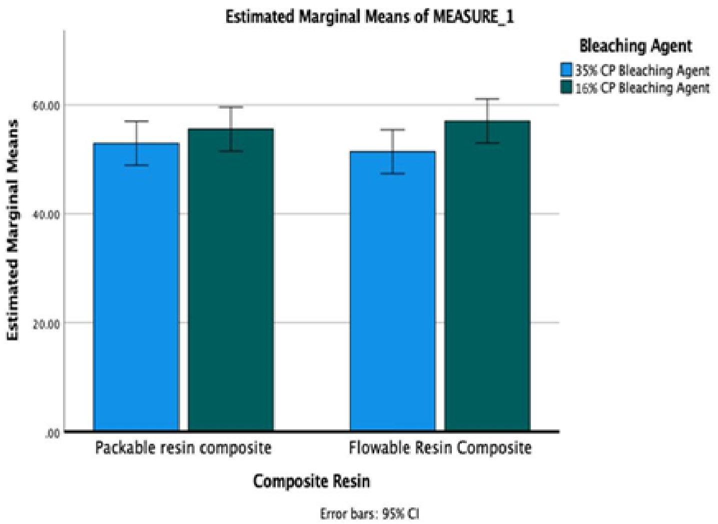

Figure 3. Estimated marginal means of Ra for studied composite resin and bleaching agents.

Between effects

For the flowable resin composite group, the surface roughness (Ra) was significantly lower before treatment compared to after, t(36) = -36.18, P < .001. Similarly, the packable resin composite group also showed significantly lower Ra before treatment than after, t(36) = -35.95, P < .001. Regarding the 16% CP bleaching agent, Ra before treatment was significantly lower than after, t(36) = -36.36, P < .001. The same pattern was observed with the 35% CP bleaching agent, where Ra before treatment was significantly lower than after, t(36) = -35.77, P < .001. The contrasts of marginal means for the Mixed Model ANOVA are provided in **(Table 3)**.

Table 3. The marginal means contrasts for each combination of within-subject variables for the mixed model ANOVA

Contrast	Difference	SE	df	t	P
Resin|Flowable resin composite					
Ra before - Ra after	-94.45	2.61	36	-36.18	< .001
Resin|Packable resin composite					
Ra before - Ra after	-93.86	2.61	36	-35.95	< .001
Bleaching agent|16% CP bleaching agent					
Ra before - Ra after	-94.92	2.61	36	-36.36	< .001
Bleaching agent|35% CP bleaching agent					
Ra before - Ra after	-93.39	2.61	36	-35.77	< .001

Between effect interactions

For the combination of flowable resin composite and 16% CP bleaching agent, the surface roughness (Ra) before treatment was significantly lower than after, t(36) = -26.46, P < .001. Similarly, for the combination of packable resin composite and 16% CP bleaching agent, Ra before treatment was significantly lower than after, t(36) = -24.96, P < .001. In the case of flowable resin composite with 35% CP bleaching agent, Ra before treatment was also significantly lower than after, t(36) = -24.71, P < .001. The same pattern was observed for packable resin composite with 35% CP bleaching agent, where Ra before treatment was significantly lower than after, t(36) = -25.88, P < .001. The contrasts of marginal means for each combination of the between-subject interactions and within-subject factors are displayed in **(Table 4)**.

Table 4. The marginal means contrasts for each combination of the between-subject interactions and within-subject factor for the mixed model ANOVA

Contrast	Difference	SE	df	t	P
Resin|Flowable resin composite: bleaching agent|16% CP bleaching agent					
Ra before - Ra after	-97.69	3.69	36	-26.46	< .001
Resin|Packable resin composite: bleaching agent|16% CP bleaching agent					
Ra before - Ra after	-92.16	3.69	36	-24.96	< .001
Resin|Flowable resin composite: bleaching agent|35% CP bleaching agent					
Ra before - Ra after	-91.21	3.69	36	-24.71	< .001
Resin|Packable resin composite: bleaching agent|35% CP bleaching agent					
Ra before - Ra after	-95.56	3.69	36	-25.88	< .001

Note. Tukey Comparisons were used to test the differences in estimated marginal means.

The hypothesis was dismissed due to significant differences observed in the main effects of resin type and bleaching agent concentration.

In esthetic dentistry, resin composites are commonly used for dental restorations, especially in the anterior region of the mouth. This material's popularity has grown because of its biocompatibility, superior mechanical properties, and fewer side effects compared to amalgam-based materials. Packable composites are often chosen for restoring cavities in classes III, IV, and V, caused by both caries and non-carious conditions. On the other hand, flowable composites are primarily used for treating class V and III cavities [16]. Consequently, this study aimed to examine how home bleaching agents affect the surface texture of packable and flowable composites.

This study focused on the Charisma Flow and Charisma Smart resin composites, using two concentrations of carbamide peroxide (CP) bleaching agents—35% and 16%. The results from surface texture analysis demonstrated that bleaching agents significantly alter the surface texture of resin-based composites, regardless of the type of bleaching agent or composite used [17]. According to ISO guidelines, the maximum force applied to a tooth ranges from 50-250 g which could potentially impact the composite's surface. Prolonged tooth brushing also contributes to resin degradation, particularly when bleaching agents are present [18]. Notably, the packable composite showed resistance to surface degradation caused by bleaching agents, regardless of the bleaching type [7]. In contrast, flowable composites were more vulnerable to surface damage due to their lower viscosity. The 35% CP bleaching agent was found to significantly increase surface roughness in both types of composites, while the 16% concentration did not show significant effects. This finding further confirms that higher concentrations of bleaching agents correlate with increased surface roughness. Similar studies have also indicated that bleaching agents, at certain concentrations, impact color stability, resin composites, and surface roughness [19]. Additionally, standard toothpaste often contains polishing and bleaching agents such as hydrogen peroxide, pyrophosphates, silica, and carbamide peroxide, which not only lighten teeth but also contribute to increased roughness, leading to sensitivity issues. Therefore, pharmaceutical and R&D professionals must address these concerns and develop improved alternatives.

Özduman *et al*. [20] conducted a study examining the surface roughness of 2 different types of packable composites exposed to varying light cure times (10, 20, and 30 seconds) before and after the application of home bleaching agents. The study, which involved 72 samples and used SEM analysis, found significant differences in surface roughness before and after the bleaching treatment, irrespective of the light exposure time. These results were consistent with those observed in our current study. Other research has similarly reported an increase in the surface roughness of restorative materials when exposed to home bleaching kits [21]. However, some studies have indicated that there is no important effect on the surface roughness of restorative materials, suggesting that they can be used without causing harm [22].

Conclusion

The findings of this study indicate that the detrimental effects of bleaching agents (gels) are linked to the degradation of resin-based restorative dental materials, as evidenced by an increase in surface roughness compared to baseline measurements. Both flowable and packable composites showed similar sensitivity to the bleaching agents. When applied to the two resin-based composites, the two different concentrations of bleaching agents produced comparable increases in roughness. It is recommended to further explore the effects of various bleaching agents, restorative material compositions, and application time intervals.

Acknowledgments: The authors wish to thank Professor Doctor Hisham Abdulwahab Mostafa and Professor Doctor Thamer Marghlani from the Faculty of Dentistry at King Abdul-Aziz University for their invaluable support. Thanks also go to the Deanship of Scientific Research (DSR) and the Advanced Technology Dental Research Laboratory at King Abdul-Aziz University, Jeddah, Saudi Arabia, for their assistance in facilitating the research.

Conflict of Interest: None

Financial Support: None

Ethics Statement: Approval for the study was granted by the IRB of the Faculty of Dentistry, King Abdulaziz University, with reference number #132-12-20.

References

1. Llena C, Villanueva A, Mejias E, Forner L. Bleaching efficacy of at home 16% carbamide peroxide. A long-term clinical follow-up study. J Esthet Restor Dent. 2020;32(1):12-8.
2. Rezende M, Loguercio AD, Kossatz S, Reis A. Predictive factors on the efficacy and risk/intensity of tooth sensitivity of dental bleaching: a multi regression and logistic analysis. J Dent. 2016;45:1-6.
3. Darriba L, Novoa L, de la Peña VA. Efficacy of different protocols for at-home bleaching: a randomized clinical trial. Am J Dent. 2017;30(6):329-34.
4. Eid HA, Togoo RA, Saleh AA, CR SP. Surface topography of composite restorative materials following ultrasonic scaling and its impact on bacterial plaque accumulation. An in-vitro SEM study. J Int Oral Health. 2013;5(3):13-9.
5. de Oliveira Lima M, Catelan A, Hernandes NM, Giorgi MC, Ambrosano GM, Lima DA. In vitro evaluation of the effect of different polishing techniques on the surface roughness of composite resins submitted to at-home and in-office bleaching procedures. J Conserv Dent. 2015;18(6):483-7.
6. Abdalla MM, Ali IA, Khan K, Mattheos N, Murbay S, Matinlinna JP, et al. The influence of surface roughening and polishing on microbial biofilm development on different ceramic materials. J Prosthodont. 2021;30(5):447-53.
7. Wang L, Francisconi LF, Atta MT, Dos Santos JR, Del Padre NC, Gonini-Júnior A, et al. Effect of bleaching gels on surface roughness of Nanofilled composite resins. Eur J Dent. 2011;5(02):173-9.
8. Chan KH, Mai Y, Kim H, Tong KC, Ng D, Hsiao JC. Resin composite filling. Materials. 2010;3(2):1228-43.
9. 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;9(2):e249.
10. Bahari M, Oskoee SS, Mohammadi N, Chaharom ME, Godrati M, Oskoee AS. Effect of different bleaching strategies on microhardness of a silorane-based composite resin. J Dent Res Dent Clin Dent Prospects. 2016;10(4):213-9.
11. Ardestani SS, Bonan RF, Mota MF, da Costa Farias RM, Menezes RR, Bonan PR, et al. Effect of the incorporation of silica blow spun nanofibers containing silver nanoparticles (SiO2/Ag) on the mechanical, physicochemical, and biological properties of a low-viscosity bulk-fill composite resin. Dent Mater. 2021;37(10):1615-29.
12. Khurshid Z, Zafar M, Qasim S, Shahab S, Naseem M, AbuReqaiba A. Advances in nanotechnology for restorative dentistry. Materials. 2015;8(2):717-31.
13. Cazzaniga G, Ottobelli M, Ionescu A, Garcia-Godoy F, Brambilla E. Surface properties of resin-based composite materials and biofilm formation: a review of the current literature. Am J Dent. 2015;28(6):311-20.
14. Hao Y, Huang X, Zhou X, Li M, Ren B, Peng X, et al. Influence of dental prosthesis and restorative materials interface on oral biofilms. Int J Mol Sci. 2018;19(10):3157.
15. Abdelaziz KM, Mir S, Khateeb SU, Baba SM, Alshahrani SS, Alshahrani EA, et al. Influences of successive exposure to bleaching and fluoride preparations on the surface hardness and roughness of the aged resin composite restoratives. Medicina. 2020;56(9):476.
16. Zhou X, Huang X, Li M, Peng X, Wang S, Zhou X, et al. Development and status of resin composite as dental restorative materials. J Appl Polym Sci. 2019;136(44):48180.
17. Navimipour EJ, Ajami AA, Oskoee SS, Kahnamou MA, Bahari M, Chaharom ME, et al.

Surface roughness of different composite resins after application of 15% Carbamide peroxide and brushing with toothpaste: an in-vitro study. Front Dent. 2019;16(1):55-61.

18. Heintze S, Forjanic M, Ohmiti K, Rousson V. Surface deterioration of dental materials after simulated toothbrushing in relation to brushing time and load. Dent Mater. 2010;26(4):306-19.
19. Esmaeili B, Zenouz GA, Khazaei F, Daryakenari G, Bizhani A. Effect of different concentrations of carbamide peroxide on the staining susceptibility of resin composites. J Conserv Dent. 2018;21(5):500-4.
20. Özduman ZC, Kazak M, Fildisi MA, Özlen RH, Dalkilic E, Donmez N. Effect of polymerization time and home bleaching agent on the microhardness and surface roughness of bulk-fill composites: a scanning electron microscopy study. Scanning. 2019;2019:2307305. doi:10.1155/2019/2307305
21. Sharafeddin F, Jamalipour GR. Effects of 35% carbamide peroxide gel on surface roughness and hardness of composite resins. J Dent (Tehran, Iran). 2010;7(1):6-12.
22. Hafez R, Ahmed D, Yousry M, El-Badrawy W, El-Mowafy O. Effect of in-office bleaching on color and surface roughness of composite restoratives. Eur J Dent. 2010;4(02):118-27. doi:10.1055/s-0039-1697819