The effect of sodium ascorbate 35% combination of surfactant 0,4% application frequency and different intracoronal bleaching on composite resin microleakage: an experimental study

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ABSTRACT

Introduction: Bleaching with hydrogen peroxide produces free radicals in dentin which can interfere with the penetration of adhesive materials and the polymerization process of composite resin, thereby increasing the occurrence of microleakage. In cases of severe discoloration, bleaching can be repeated more than once to maximize the color change. Repeated bleaching will increase free radical residues, so more antioxidants are needed. The purpose of this study was to examine the effect of the frequency of application of sodium ascorbate 35% combined with surfactant 0,4% at different intra coronal bleaching frequencies on microleakage of composite resin. **Methods:** The research sample consisted of 30 premolars prepared with class I cavities with a diameter of 3 mm and a depth of 6 mm. The samples were divided into 2 groups, group I was bleached twice while group II was bleached three times, after bleaching each group was divided into 3 subgroups, group A was incubated for 7 days then filled with composite resin, group B was applied with sodium ascorbate 35% combined with surfactant 0,4% twice then filled with composite resin, group C was applied with sodium ascorbate 35% combined with surfactant 0,4% three times then filled with composite resin. All samples were observed for microleakage using a scanning electron microscope (SEM). **Results:** The results of the two-way ANOVA test showed that there was a significant effect of the frequency of sodium ascorbate application and the frequency of bleaching on microleakage with a value of $p=0.001$ ($p<0.05$) and there was an interaction between the frequency of sodium ascorbate 35% combined with 0,4% surfactant application and the frequency of bleaching on microleakage of composite resin. **Conclusion:** The frequency of application of sodium ascorbate 35% combined with surfactant 0,4% and different intracoronal bleaching has an effect on the level of composite resin microleakage.

Keywords

frequency of application, H_2O_2; sodium ascorbate, microleakage

Efek frekuensi aplikasi sodium askorbat 35% kombinasi surfaktan 0,4% dan bleaching intrakoronal yang berbeda terhadap kebocoran mikro resin komposit: studi eksperimen

ABSTRAK

Pendahuluan: *Bleaching dengan hidrogen peroksida menghasilkan radikal bebas pada dentin yang dapat mengganggu penetrasi bahan adhesif dan proses polimerisasi resin komposit sehingga meningkatkan terjadinya kebocoran mikro. Pada kasus perubahan warna yang berat, bleaching dapat diulang sebanyak lebih dari satu kali untuk memaksimalkan perubahan warna. Bleaching yang dilakukan secara berulang akan meningkatkan residu radikal bebas, sehingga dibutuhkan antioksidan yang lebih banyak. Tujuan penelitian ini untuk menguji pengaruh frekuensi aplikasi sodium askorbat 35% kombinasi surfaktan 0,4% pada frekuensi bleaching intrakoronal yang berbeda terhadap kebocoran mikro resin komposit.* ***Metode:*** *Sampel penelitian berupa 30 premolar yang di preparasi kavitas kelas I dengan diameter 3 mm kedalaman 6 mm. Sampel dibagi menjadi 2 kelompok, kelompok I dilakukan bleaching dua kali sedangkan kelompok II dilakukan bleaching tiga kali, pasca dilakukan bleaching, masing-masing kelompok dibagi menjadi 3 sub kelompok yaitu kelompok A di inkubasi selama 7 hari kemudian di tumpat resin komposit, kelompok B diaplikasi sodium askorbat 35% kombinasi surfaktan 0,4% dua kali kemudian di tumpat resin komposit, kelompok C diaplikasi sodium askorbat 35% kombinasi surfaktan 0,4% tiga kali kemudian di tumpat resin komposit. Seluruh sampel dilakukan pengamatan kebocoran mikro dengan menggunakan scanning electron microscope (SEM).* ***Hasil:*** *Hasil uji ANAVA dua jalur menunjukkan bahwa terdapat pengaruh yang signifikan frekuensi aplikasi sodium askorbat dan frekuensi bleaching terhadap kebocoran mikro dengan nilai $p=0,001$ ($p<0,05$) dan terdapat interaksi antara frekuensi aplikasi sodium askorbat 35% kombinasi surfaktan 0,4% dan frekuensi bleaching terhadap kebocoran mikro resin komposit.* ***Simpulan:*** *Frekuensi aplikasi sodium askorbat 35% kombinasi surfaktan 0,4% dan bleaching intrakoronal yang berbeda berpengaruh terhadap tingkat kebocoran mikro resin komposit.*

Kata kunci

frekuensi aplikasi, H_2O_2, sodium askorbat, kebocoran mikro

INTRODUCTION

Tooth discoloration frequently becomes a health concern among individuals. Management of tooth discoloration in non-vital dentin can be performed by applying intracoronal bleaching, such as the walking bleach method. This technique involves placing hydrogen peroxide into the pulp chamber, which initiates oxidative reaction.[1] The penetration of hydrogen peroxide into dentin is primarily facilitated by its low molecule mass. Serving as strong oxidative agent, it breaks down the bonds in organic and inorganic compounds within the dentinal tubulus.[2]

Repeated bleaching application are often required for sever tooth discoloration, thereby increasing the bleaching output.[3] However, the bleaching materials may leave residual free radicals within the tooth structure. This residual presence can disrupt the resin tag penetration and the polymerization of the composite resin. As higher concentrations of bleaching materials are used, the accumulation of residual free radicals also increases, which may lead to the bonding failure and the polymerization of the composite resin.[4]

Generally, treatment is followed by coronal composite resin restoration after bleaching to protect the root canal therapy, preventing bacterial reinfection and microleakage; therefore, it is recommended that residual hydrogen peroxide be removed completely from the pulp chamber prior to composite resin placement.[5-7] The removal of residual hydrogen peroxide can be achieved using antioxidants, including α-tocopherol, Proanthocyanidins, green tea and catalase.[8] Residual free radicals generated from the bleaching procedure may compromise the quality of composite resin restoration if it is performed immediately after bleaching.[9] Free radicals are highly reactive molecules with a single unpaired electron that can break down large pigmented molecules into smaller, less pigmented fragments.[10]

Composite resin restoration is recommended 1 to 3 weeks following the bleaching procedure to allow sufficient time for free radicals to completely dissipate.[11,12] However, delaying the restorative treatment prolongs the overall clinical timeline, an issue that can be mitigated by applying antioxidant agents. A study by Nugraheni[13] demonstrated that an 35% sodium ascorbate antioxidant solution is effective in eliminating residual free radicals following intracoronal bleaching.[13] This approach can shorten the overall treatment duration, including the direct restoration that is ultimately required.[14] Sodium ascorbate is an ascorbic acid mineral salt widely used for its potent antioxidant activities.[15] It exhibits high antioxidant activities with low toxicity.[16] Furthermore, sodium ascorbate is biocompatible and water-soluble, which allows its extensive clinical application; however, it remains unstable in the presence of water and oxygen.[8]

The instability of sodium ascorbate necessitates repeated applications; one approach to address this limitation is the incorporation of a surfactant into the sodium ascorbate solution. The addition of Tween 80 surfactant to 35% sodium ascorbate can enhance the penetration of the solution into the dentin surface. This optimizes the capacity of 35% sodium ascorbate to bond free radicals, thereby increasing the shear bond strength and the tensile bond strength of the composite resin to the dentin surface.[17] This improvement in bond strength can effectively reduce the occurrence of microleakage in composite resin restoration after bleaching procedure. A study conducted by Yuniaty revealed that the group receiving 2 applications of 35% sodium ascorbate combined with 0.4% surfactants exhibited small microleakage.[18]

Teeth with severe discoloration degree required multiple bleaching procedures; however repeated bleaching procedures may increase exposure to the bleaching material, subsequently leading to a higher accumulation of residual free radicals. To neutralize this larger volume of residues, a greater number of antioxidant applications are necessitated. Therefore, further study is required to evaluate the effect of different application frequencies of 35% sodium ascorbate combined with 0.4% surfactant, across varying intracoronal bleaching frequencies, on composite resin microleakage. Although several

studies have investigated the effect of intracoronal bleaching sessions on the composite resin microleakage have been conducted, research regarding the effective application frequency of 35% sodium ascorbate combined with 0.4% surfactant across varying bleaching frequencies remains limited. In this study, it was hypothesized that lower microleakage would be observed in teeth treated with three applications of 35% sodium ascorbate combined with 0,4% following intracoronal bleaching sessions, compared to those treated with two applications.

This study was conducted bleaching procedures to two sample groups. Group I received two sessions, while Group II received three sessions. Following the bleaching procedures, each group was further divided into three subgroups. Subgroup A was incubated for 7 days and subsequently restored with composite resin. Subgroup B received two applications of 35% sodium ascorbate combined with 0,4% surfactant prior to composite resin restoration. Subgroup C received three applications of 35% sodium ascorbate combined with 0,4% surfactant prior to composite resin restoration, a comparative evaluation that has not previously investigated. The purpose of this study is to analyze the effective application frequencies of 35% sodium ascorbate combined with 0.4% surfactants, across varying frequencies of intracoronal bleaching sessions, on composite resin microleakage.

METHODS

This study is an *in vitro* laboratory experiment. The sample size consisted of 30 human premolars that met the inclusion criteria. This sample size was determined using Federer formula to establish the minimum required number of samples. The specimens were collected from several dental clinic in Yogyakarta, based on the following criteria: premolars extracted for orthodontic treatment within a maximum period of 2 months, intact crowns and roots, free of caries, cracks, or vertical and horizontal fractures, and with completely formed apices.

The study was conducted over approximately 3 months at the Integrated Research Laboratory of the Faculty of Dentistry, the Laboratory of the faculty of Pharmacy, and the Integrated Research and Testing Laboratory at Universitas Gadjah Mada, Yogyakarta. For the preparation of antioxidant gel from 35% sodium ascorbate combined with 0.4% surfactant, 0.5 grams of CMC-Na powder and 3.5 grams of sodium ascorbate powder were weighed using a digital scale.

The procedure began by dissolving the CMC-Na power in 10 mL of distilled water pre-heated at 60°C using a water-bath method. The mixture was then transferred into a beaker and homogenized using a magnetic hot plate stirrer until clear solution was achieved. Subsequently, 3.5 grams of sodium ascorbate were placed into a beaker, to which 4 mL of CMC-Na gel were added. The components were the thoroughly blended using a glass stirrer at room temperature.

The sodium ascorbate gel was transferred from a beaker glass into a test tube, and additional CMS-Na gel was incorporated to bring the total volume of 10 ml. The mixture was then completely homogenized using a vortex mixer. The 35% sodium ascorbate gel combined with 0.4% surfactant was placed into an airtight, dark amber glass bottle and stored in a refrigerator at 4°C.[22]

The tooth crowns were measured 2 mm apical to the cemento enamel junction (CEJ) and 4 mm coronal to the CEJ (Figure 1a). They were then sectioned using *double faced* diamond disc bur (Figure 1b). Subsequently, a Class I cavity with a diameter 3 mm was prepared on the occlusal surface of each premolar. The cavity access was opened using round diamond bur (Figure 1c) and then widened using a 33-mm diameter wheel diamond bur to reach a depth of 6 mm (Figure 1d).

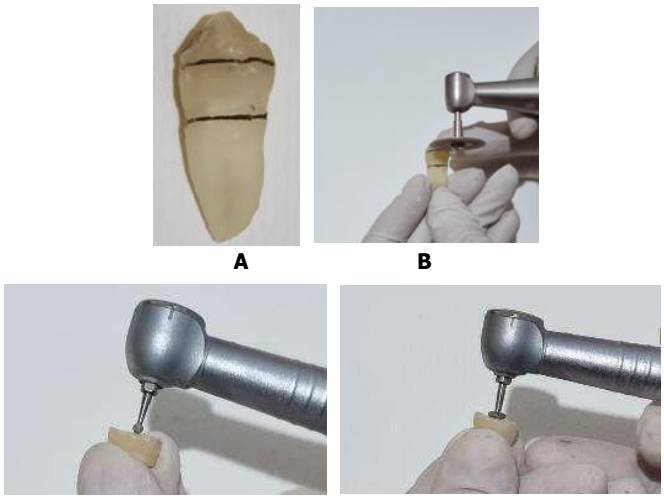


Figure 1. A) Sample after measurement and marking with a permanent marker; B) Sample sectioning process; C) Access opening of the pulp chamber using a round diamond bur; D) Cavity enlargement using a wheel diamond bur.

A 2-mm thick cervical barrier of resin modified glass ionomer cement (RMGIC) was applied to all specimens (Figure 2a). This barrier was subsequently activated using light curing unit for 20 seconds from the occlusal direction. Following this, the scpecimens were embedded into baseplate wax (Figure 2b).

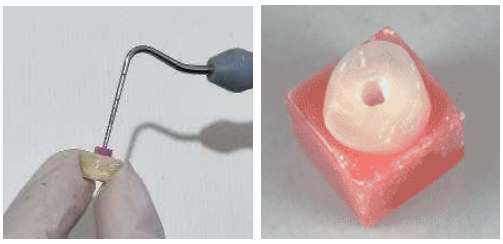


Figure 2. A) Measurement of RMGIC to obtain a 2-mm thickness at the cervical region; B) Embedding of the sample in a red wax box.

All specimens underwent an intra coronal bleaching procedure using 35% hydrogen peroxide application. A 0.01 mL bleaching agent was applied once by inserting the material directly into the cavity. The cavity was then sealed with a temporary restoration, and the specimen was immersed in a sealed tube containing artificial saliva (pH 7). The tubes were then placed in an incubator at 37°C for 5 days (Figure 3).

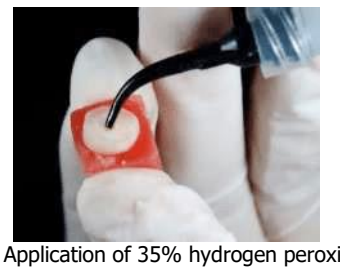
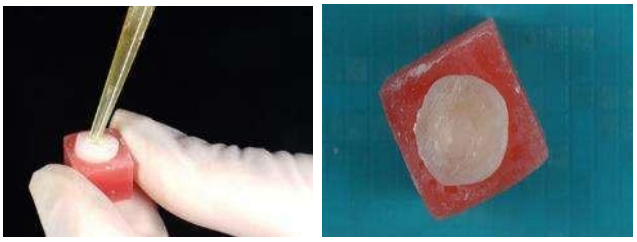


Figure 3. Application of 35% hydrogen peroxide

All specimens underwent a second bleaching application. The temporary restoration was removed, and the cavity was rinsed with a 15 mL of distilled water solution using a disposable syringe, then dried for 10 seconds with a three-way syringe. Subsequently, the 35% hydrogen peroxide bleaching agent was reapplied following the identical protocols as

the previous step. The samples were divided into two groups. Group I underwent two bleaching sessions, whereas group II underwent three bleaching sessions using the identical protocols as the previous step.

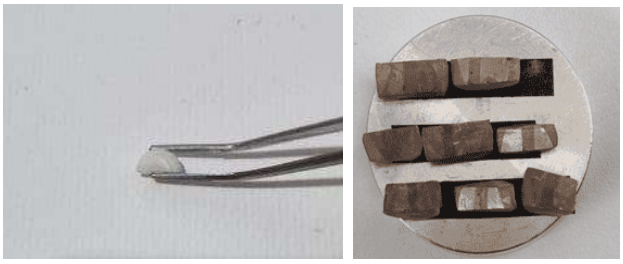
Furthermore, each main group was subdivided into three subgroups: In Subgroup A, no 35% sodium ascorbate gel combined with 0.4% surfactants was applied, and restoration was delayed for 7 days. In subgroup B, 35% sodium ascorbate combined with 0.4% surfactant was applied two times, whereas in subgroup C the application was conducted three 3 times (Figure 4a). For both subgroup B and C, each application consisted of 0.02 mL of the gel for 5 minutes, followed by rinsing with 15 mL of distilled water, after which the composite resin restoration was immediately placed (Figure 4b).



A B

Figure 4. A) Application of the antioxidant agent into the cavity using a micropipette; B) Sample after treatment and restoration with composite resin

The teeth were sectioned longitudinally from the buccal to the lingual direction, passing through the composite resin-restored cavity. Subsequently, a 3 mm-reduction was performed using a double-faced diamond disc bur (Figure 5a). The specimens were placed onto metal stubs for gold coating using a Smart Coater (Figure 5b). Following the gold coating process, the specimens were placed into the scanning electron microscope (SEM) to observe microleakage at a magnification of 3000 x.



A B

Figure 5. A) Sample after sectioning into buccal and lingual halves; B) Sample after gold coating.

Microleakage was evaluated by observing the gap formed between the restoration and the cavity walls. The teeth that had been previously sectioned longitudinally from the buccal to the lingual direction, passing the resin-restored cavity, were subsequently examined using the SEM. Microleakage was measured using ImageJ software. Data analysis was performed using a two-way analysis of variance (ANOVA) at 95% confidence level, followed by Least Significant Difference (LSD) post hoc test.

RESULTS

Microleakage is a gap formed between the restoration and the cavity walls, which is observed using Scanning Electron Microscope (SEM) at a magnification of 3000X. (Figure 6). Microleakage was quantified using ImageJ software, followed by making measurement line across the gaps formed between the composite resin and dentin, which had been previously calibrated. The length of the connected lines was recorded in micrometers (μm).

Five measurement lines were drawn across the widest areas, and the values were averaged to determine the mean microleakage width for each specimen.

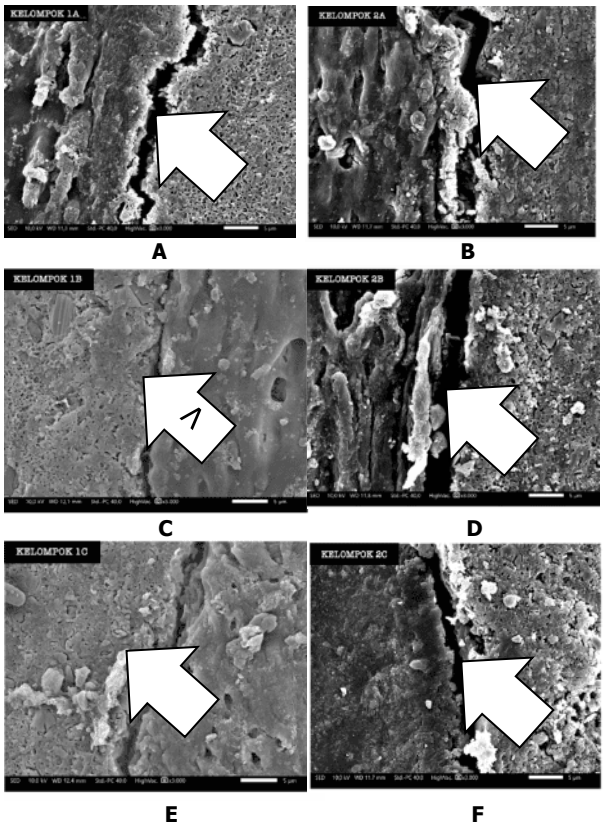


Figure 6. SEM micrographs at 3000× magnification showing microleakage (arrows) in each group: A) Group IA, B) Group IIA, C) Group IB, D) Group IIB, E) Group IC, and F) Group IIC.

Microleakage levels were measured in micrometers (μm). The measurements were obtained by drawing five lines across the widest microleakage area observed in each study sample.

Table 1. Results of the Shapiro–Wilk and Levene's tests for microleakage in teeth following intracoronal bleaching after treatment according to the respective experimental groups.

Treatment Group	*Shapiro-Wilk*	Levene test
Group IA	0.289*	
Group IB	0.594*	
Group IC	0.808*	0.126*
Group IIA	0.400*	
Group IIB	0.754*	
Group IIC	0.383*	

Note: *= significant if p>0.05; Group IA = 2× bleaching & 7-day restoration delay; Group IB = 2× bleaching & 2× (35% SA + 0.4% surfactant); Group IC = 2× bleaching & 3× (35% SA + 0.4% surfactant); Group IIA = 3× bleaching & 7-day restoration delay; Group IIB = 3× bleaching & 2× (35% SA + 0.4% surfactant); Group IIC = 3× bleaching & 3× (35% SA + 0.4% surfactant)

The microleakage measurements revealed that the values for the experimental groups were as follows: Group IA (2.91±0.31 μm), Group IB (1.86±0.23 μm), Group IC (2.00±0.2 μm), Group IIA (3.71±0.52 μm), Group IIB (3.57±0.61 μm), and Group IIC (2.80±0.48 μm). The Shapiro-Wilk test results indicated a p-value > 0,05, demonstrated that the data were normally distributed. Furthermore, Levene's test confirmed homogenous variance with a value of 0,126 (p>0,05). Consequently, the obtained data met the criteria for

parametric analysis using a two-way analysis of variance (ANOVA), as presented in Table1 dan Table2.

Table 2. Results of the Two-Way ANOVA for Microleakage in Teeth Following Intracoronal Bleaching After Treatment According to the Experimental Groups

	db	Jumlah Kuadrat	Rerata Kuadrat	p
Sodium_Ascorbate	2	4.253	2.127	0.001*
Bleaching	1	9.118	9.118	0.001*
Sodium_Ascorbate *Bleaching*	2	1.392	0.696	0.039*
Error	24	4.488	0.187	
Total	30	256.814		

Note: * : significant

As demonstrated in Table 2, the sodium ascorbate application frequency variable yielded a *p*-value of 0.001 ($p<0.05$), indicating a significant difference in microleakage based on the frequency of sodium ascorbate application. Regarding the bleaching frequency variable, a *p*-value of 0.001 ($p<0.05$) was obtained, denoting a significant difference in microleakage between the two- and three-time bleaching groups. Furthermore, a significant interaction was observed between the frequency of sodium ascorbate application and the bleaching frequency ($p =0.039$, $p<0.05$). Consequently, a Least Significant Difference (LSD) post hoc test was performed to determine the specific group pairs that exhibited statistically significant differences (Table 2).

Table3. Hasil Uji *Post hoc Least Significant Difference* kebocoran mikro pada gigi pasca *bleaching* intrakoronal setelah dilakukan perlakuan sesuai kelompok

Group Comparison		Mean Difference	P
Group IA	Group IB	1.0494000*	0.001*
	Group IC	0.9086000*	0.003*
	Group IIA	-.7978000*	0.008*
	Group IIB	-.6624000*	0.023*
	Group IIC	0.1104000	0.690
Group IB	Group IC	-0.1408000	0.611
	Group IIA	-1.8472000*	0.001*
	Group IIB	-1.7118000*	0.001*
	Group IIC	-0.9390000*	0.002*
Group IC	Group IIA	-1.7064000*	0.001*
	Group IIB	-1.5710000*	0.001*
	Group IIC	-.7982000*	0.008*
Group IIA	Group IIB	0.1354000	0.625
	Group IIC	0.9082000*	0.003*
Group IIB	Group IIC	0.7728000*	0.009*

Note: * : significant ; Group IA = 2× bleaching & 7-day restoration delay; Group IB = 2× bleaching & 2× (35% SA + 0.4% surfactant); Group IC = 2× bleaching & 3× (35% SA + 0.4% surfactant); Group IIA = 3× bleaching & 7-day restoration delay; Group IIB = 3× bleaching & 2× (35% SA + 0.4% surfactant); Group IIC = 3× bleaching & 3× (35% SA + 0.4% surfactant)

The post hoc test results presented in Table 3 indicated statistically significant differences in the mean values ($p<0.05$) across almost all group pairs, except for the following pairs: Group IA versus Group IIC, Group IB versus Group IC, and Group IIA versus Group IIB.

DISCUSSION

The results of this study demonstrated that the lowest mean microleakage value was found in Group IB (two bleaching sessions combined with two sodium ascorbate applications), whereas Group IIA (three bleaching sessions followed by a 7-day delayed restoration) exhibited the highest mean microleakage. The two-way ANOVA results revealed that different frequencies of intracoronal bleaching significantly influenced the microleakage of the composite resin. A statistically significant difference in mean

microleakage was observed between Group I (two bleaching sessions) and Group II (three bleaching sessions). These findings align with a study by Llena et al., which showed that prolonged application times and repetitive applications can enhance the diffusion of hydrogen peroxide.[19] This enhanced diffusion subsequently increases the accumulation of post-bleaching free radical residues. Hydrogen peroxide has a low molecular weight, allowing it to easily penetrate enamel and dentin surfaces.[20] Performing the bleaching procedure three times resulted in greater microleakage, which can likely be attributed to the larger number of free radicals.

The free radical residues react with both the organic and inorganic components of enamel and dentin, triggering structural alterations in the dental tissue. This morphological change, which is driven by the loss of inorganic components, is directly linked to a reduction in dentin strength.[21] A study by Nugraheni et al. demonstrated a significant decrease in calcium and phosphorus percentages following bleaching procedures.[13] Dentin subjected to prolonged exposure and higher concentrations of hydrogen peroxide is highly susceptible to a greater depletion of these minerals. Ultimately, alterations in the dentin mineral content alongside the remaining free radicals within the tooth structure may compromise the bond strength, thereby impairing adhesion with the restorative material and leading to micro gap formation.[21]

Bleaching affects organic component, inducing collagen denaturation, which subsequently compromises the resin bind strength leading to increased microleakage.[22] The presence of residual free radicals after bleaching sessions reacts with the composite resin monomers, causing premature termination. This process is responsible for low adhesion of the composite resin to dentin. These free radical residues inhibit resin polymerization, thereby reducing the bond strength of the resin to the tooth structure. The chemical reaction occurring during the bleaching process can alter tooth surface, interfere with resin tag formation, and negatively impact the adhesion of restorative materials into the substrate.[23] Microscopic analysis reveal morphological changes in the hybrid layer and resin tag following the bleaching with 35% hydrogen peroxide. Specifically, it can be concluded that the enamel thins, and the resin tag become fewer in number, shorter, fragmented and poorly defined.[24]

The two-way ANOVA result also showed a significant effect on the frequencies of sodium ascorbate application to the microleakage. A smaller microleakage value was found among the groups with sodium ascorbate applications, compare to those with 7-day delayed restoration. Because repetitive bleaching sessions increased the formation of free radicals, a larger number of antioxidants is required. These findings are in line with previous research stating that the concentration level of sodium ascorbate is directly proportional to the number of free radicals released by the bleaching agents.[13]

Applying a bigger amount of sodium ascorbate may increase the antioxidant volume, thus enhancing the effectiveness of binding residual free radicals within the dentinal tubules. Eliminating these free radicals from the tooth structure improves adhesion between the tooth and the composite resin restoration after bleaching.[22] Furthermore, combining sodium ascorbate gel with a surfactant reduces surface tension, allowing the antioxidant to penetrate the dentin much more easily.[25]

A study by Arlini showed that adding 0.4% surfactant to 35% sodium ascorbate influences the length of resin tag restoration composite resin after bleaching. The application of this component allows for deeper penetration into the dentinal tubules, effectively binding free radical residues trapped inside. Once the tubules are cleared of these residues, the resin monomers in adhesive can polymerize more effectively, resulting in longer resin tags. Ultimately, these longer resin tags contribute to a stronger bong between composite resin restoration and the tooth.[26]

For Group I, the LSD post hoc test results revealed significant differences in microleakage values among subgroups IA, IB, and IC. In subgroup IA, with a 7-day delayed restoration showed a larger microleakage, compared to Subgroups IB and IC. These findings align with a study by Piemjai et al. (2017), which showed storing the bleached,

extracted teeth in artificial saliva for 7 days was insufficient to reduce the adverse effect of the bleaching on microleakage at the tooth resin interface.[27] This is likely because a 7-day delay does not provide enough time for the free radical residues to completely dissipate.

In subgroup IB, two applications of sodium ascorbate resulted in a slightly lower microleakage value compared to subgroup IC. Though the difference was not statistically significant. This is supported by Ismail et al. (2017), who stated that the concentration of a sodium ascorbate required to clear free radicals must be directly proportional to the concentrations of hydrogen peroxide.[28]

The LSD post hoc test results also revealed significant differences in microleakage between Groups IIA and IIC, as well as between Groups IIB and IIC. Both Groups IIA and IIB exhibited higher microleakage values compared to Group IIC, while no significant difference was found between Groups IIA and IIB. This suggests that applying sodium ascorbate twice after three bleaching sessions is still insufficient to fully eliminate residual free radicals. Thoroughly removing these free radical residues from the dentin optimizes the polymerization of the composite resin and adhesive agent, thereby ensuring proper hybrid layer formation and minimizing microleakage.

This study indicates that greater exposure to bleaching agents needs more frequent applications of sodium ascorbate. A higher frequency of sodium ascorbate application enhances its antioxidant effect and the capacity to eliminate free radicals, thereby shortening the waiting period before restoration.[29] In this study, the sodium ascorbate was applied by dropping it into the cavity using a pipette without agitation, which may have limited its penetration into the dentinal tubules. Previous research has shown that the passive application of antioxidants, simply by dropping the solution, can interrupt the bond between the restorative material and the dentin surface. Therefore, active agitation by scrubbing the sodium ascorbate with a micro brush would better facilitate the removal of residual free radicals.[29]

A limitation of this study is that the sodium ascorbate was applied passively by dropping it into the cavity with a pipette without agitation, which may have restricted its penetration into the dentinal tubules. According to previous research, continuous agitation of the ascorbate solution enhances its antioxidant effect on bleached enamel surfaces. Furthermore, repeating the antioxidant application alongside active agitation significantly improves its overall effectiveness during treatment.[30]

CONCLUSION

The frequencies of the 35% sodium ascorbate combined with 0.4% surfactant applications, as well as the frequency of intracoronal bleaching sessions, significantly affect the microleakage of composite resin restorations. Applying sodium ascorbate reduces microleakage compared to a simple delayed restoration protocol, particularly under conditions of repeated intracoronal bleaching. Furthermore, a significant interaction was found between the frequency of sodium ascorbate application and the number of bleaching sessions regarding their effect on resin microleakage. Clinically, these findings imply that using a 35% sodium ascorbate and 0.4% surfactant combination immediately after intracoronal bleaching serves as an effective approach to minimize microleakage in composite resin restorations.

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Ethical Approval: Ethical approval for this study was obtained from the Research Ethics Committee of the

Faculty of Dentistry–Prof. Soedomo Dental Hospital, Universitas Gadjah Mada, Yogyakarta, Indonesia(Approval No.61/UNI/KEP/FKG-RSGM/EC/2024)

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of the Research Ethics Committee, Faculty of Dentistry–Prof. Soedomo Dental Hospital, Universitas Gadjah Mada, Yogyakarta, Indonesia (Approval No. 61/UNI/KEP/FKG-RSGM/EC/2024)

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare that they have no conflict of interest.

REFERENCES

1. Oliveira D. *Color science and shade selection in operative dentistry*. USA: Springer; 2022. p. 75–80. https://doi.org/10.25241/stomaeduj.2022.9(3-4).bookreview.1
2. Amer M. Intracoronal tooth bleaching – a review and treatment guidelines. Aust Dent J. 2023. https://doi.org/10.1111/adj.13000
3. Ozdemir ZM, Surmelioglu D. Effects of different bleaching application time on tooth color and mineral alteration. Ann Anatomy. 2020:1-8. https://doi.org/10.1016/j.aanat.2020.151590
4. Gopikrishna V. *Grossman's endodontic practice*. 14th ed. India: Wolters Kluwer; 2021. p. 480–488. https://doi.org/10.4103/0970-7212.318141
5. Yusri, Trilaksana AC, Rovani CA. Antioxidant effectivity to decrease coronal microleakage of composite resin restoration after intracoronal bleaching. J Dentomaxillofac Sci. 2016;1(3):158–62. https://doi.org/10.15562/jdmfs.v1i3.309
6. Karadas M, Demirbuga S. Influence of short-time antioxidant application on the dentine bond strength after intracoronal bleaching. Microsc Res Tech. 2019;82(10):1–8. https://doi.org/10.1002/jemt.23337
7. Greenwall L. *Tooth whitening techniques*. Boca Raton: CRC Press; 2017. p. 24–172. https://doi.org/10.1201/9781315365503
8. Olmedo DE, Kury M, Bruna BA, Cavalli V. Use of antioxidants to restore bond strength after tooth bleaching with peroxides. Eur J Oral Sci. 2021:1–19. https://doi.org/10.1111/eos.12773
9. Coppla FM, Freire A, Bittencourt B, Vega AA, Banitez V, Calixto AL, et al. Influence of simplified, higher-concentrated sodium ascorbate application protocols on bond strength of bleached enamel. J Clin Exp Dent. 2019;11(1):21–6. https://doi.org/10.4317/jced.55153
10. Hardan L, Bourgi R, Suarez CEC, Ghaleb M, Kharma K, Harouny R, et al. Can sodium ascorbate increase the in vitro bond strength of the interface between a composite and bleached enamel. Coatings. 2023:1–6. https://doi.org/10.3390/coatings13061064
11. Hargreaves KM, Berman LH, Rotstein I. *Cohen's pathways of the pulp*. 11th ed. California: Elsevier; 2016. p. 1008–1021.
12. Torabinejad M, Fouad AF, Shabahang S. *Endodontics: principles and practice*. 6th ed. USA: Elsevier; 2021. p. 368–381.
13. Nugraheni T, Nuryono N, Sunarintyas S, Mulyawati E. Composite resin shear bond strength on bleached dentin increased by 35% sodium ascorbate application. Dent J (Maj Ked Gigi). 2018;50(4):178–82. https://doi.org/10.20473/j.djmkg.v50.i4.p178-182
14. Lopes AL, Ribeiro ME, Barbosa HJ, Rocha MP, Junior MH, Loretto SC. Does the elapsed time from bleaching and the use of sodium ascorbate influence the bond strength of resin cement to bleached enamel. Materials (Basel). 2023:1–7. https://doi.org/10.3390/ma16186328
15. Moradian M, Saadat M, Shiri MH, Sohrabniya F. Comparative evaluation of post-bleaching application of sodium ascorbate, alpha-tocopherol, and quercetin on shear bond strength. Clin Exp Dent Res. 2022:1598–602. https://doi.org/10.1002/cre2.655
16. Feiz A, Mosleh H, Nazeri R. Effect of antioxidant agents on shear bond strength after bleaching: a systematic review. J Mech Behav Biomed Mater. 2017;71:156–64. https://doi.org/10.1016/j.jmbbm.2017.03.010
17. Yulianasari S, Santosa P, Nugraheni T. Effect of surfactant concentration in sodium ascorbate on contact angle and tensile bond strength after bleaching. Maj Ked Gigi Indones. 2022;8(1):59–69. https://doi.org/10.22146/majkedgiind.62466
18. Yuniaty M. Pengaruh frekuensi aplikasi penambahan surfaktan 0,4% dalam sodium askorbat 35% terhadap kebocoran mikro resin komposit pasca bleaching. Yogyakarta: Universitas Gadjah Mada; 2021.
19. Llena C, Esteve I, Forner L. Effect of hydrogen and carbamide peroxide on enamel morphology and mineral composition: in vitro study. J Contemp Dent Pract. 2017;18(7):576–82. https://doi.org/10.5005/jp-journals-10024-2087
20. Altinisik H, Akgül S, Nezir M, Özcan S, Özyurt E. The Effect of In-Office Bleaching with Different Concentrations of Hydrogen Peroxide on Enamel Color, Roughness, and Color Stability. Materials. 2023;16(4):1-10. https://doi.org/10.3390/ma16041389
21. Cavalli V, Sebold M, Shinohara MS, Pereira NP, Giannini M. Dentin bond strength and nanoleakage after intracoronal bleaching. Microsc Res Tech. 2018;81(4):4–8. https://doi.org/10.1002/jemt.22995
22. Yasin M, et al. The influence of dental bleaching techniques on microleakage of composite resin restoration: a systematic review. JUMMEC. 2024;2024(1):311–23. https://doi.org/10.22452/jummec.sp2024no1.32
23. Cortez TV, Ziotti IR, Scatolin SR, Corona SA, Souza Gabriel AE. Protocols for sodium ascorbate application on intracoronary dentin bleached with high-concentrated agent. J Conserv Dent. 2018;21(1):26–30. https://doi.org/10.4103/JCD.JCD_80_17
24. Ghaleb M, Orsini G, Putignano A, Dabbagh S, Haber G, Hardan L. Effect of bleaching protocols with/without sodium ascorbate on bond strength. Materials (Basel). 2020;13(12):1–10. https://doi.org/10.3390/ma13122710
25. Han SH, Park SH. Incremental and bulk-fill techniques in different cavity configurations. Oper Dent. 2018;43(6):631–41. https://doi.org/10.2341/17-279-LR
26. Arlini R. Pengaruh sodium askorbat 35% kombinasi surfaktan 0,4% terhadap panjang resin tag pasca bleaching intrakoronal. Yogyakarta: Universitas Gadjah Mada; 2023.
27. Piemjai M, Lenglerdphol S. Effect of 38% hydrogen peroxide bleaching on marginal seal. J Esthet Restor Dent. 2017;30(2):1–7. https://doi.org/10.1111/jerd.12354
28. Ismail EH, Kilinc E, Hardigan PC, Rothrock JK, Thompson JY, Godoy CG. Effect of sodium ascorbate on composite bond strength following bleaching. J Contemp Dent Pract. 2017;18(10):874–80. https://doi.org/10.5005/jp-journals-10024-2142
29. Lobo S, Santos IC, Delgado AH, Proenca L, Polido M, Azul AM, Mendes JJ. Antioxidant pre treatments are able to reduce waiting time

for restorative treatment after dental bleaching: a microtensile bond strength exploratory study. Appl Adhes Sci. 2021; 9(4):1-10. http://10.1186/s40563-021-00134-x
30. Sadeghian S, Fathpour K, Biglari M. Effect of sodium ascorbate on shear bond strength of orthodontic brackets to bleached enamel. Dent Res J. 2023;20(28):1–6. https://doi.org/10.4103/1735-3327.369630