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Does sodium ascorbate improve bond strength after dental bleaching techniques?

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Abstract

Objective: To summarize and discuss the available information concerning the effectiveness of sodium ascorbate in improving bond strength after dental bleaching procedures.

Methods: Information of original articles or reviews listed in PubMed database using searching terms: ("sodium ascorbate" OR antioxidant) AND (bleaching OR hydrogen peroxide OR carbamide peroxide), were included in the review.

Results: Most of studies revealed that sodium ascorbate could restore the altered redox potential of the oxidized bonding substrate, thus reversing the compromised bonding. However, several protocols of this antioxidant have been used in combination with different peroxide concentrations and exposure time to bleaching agents.

Conclusion: Studies should be conducted to establish an appropriate application protocol and to evaluate the effect of sodium ascorbate in other dental properties.

Key words: Tooth bleaching; Antioxidants; Bleaching agents; Dental bonding

O ascorbato de sódio promove a resistência de união após técnicas de clareamento dental?

Resumo

Objetivo: Resumir e discutir as informações disponíveis sobre a eficácia de ascorbato de sódio em promover a resistência de união após os procedimentos de clareamento dental.

Métodos: Informações de artigos originais ou revisões constados no banco de dados PubMed usando termos de pesquisa: ("ascorbato de sódio" OR antioxidantes) e (clareamento dental OR "peróxido de hidrogênio" OR "peróxido de carbamida"), foram incluídos na revisão.

Resultados: A maioria dos estudos revelam que o ascorbato de sódio pode restaurar o potencial redox alterado do substrato de ligação oxidada, revertendo assim a ligação comprometida. No entanto, vários protocolos de aplicação do presente antioxidante têm sido utilizados, em associação com diferentes concentrações de peróxido e o tempo de exposição aos agentes de branqueamento.

Conclusão: Mais estudos devem ser realizados para estabelecer um protocolo de aplicação adequado e com intuito de avaliar o efeito de ascorbato de sódio em outras propriedades dentárias.

Palavras-chave: Clareamento dental; Antioxidantes; Agentes clareadores; Colagem dentária

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Introduction

It is well known that bleaching treatments decrease the bond strength of composite to enamel and dentin when bonding procedure was performed immediately after bleaching [1-3]. This reduction could be explained by the presence of residual peroxide released from the bleaching agent, which inhibits resin polymerization [1,2]. In addition, the enamel pores, dentin, and dentinal fluid could theoretically act as a peroxide/oxygen reservoir, which results in the concentration of oxygen on the enamel surfaces that prevents the complete cure of some resin tags [3]. These changes seem to be both time- and concentration-dependent.

A time delay of 24 hours to 4 weeks has been proposed after bleaching to perform the restorative procedure [2,4]. Clinically, this can be a long period for patients seeking cosmetic treatment immediately after bleaching. Several studies have suggested the application of sodium ascorbate (SA) to improve bond strength to bleached teeth [5-30]. SA is a sodium salt of ascorbic acid with neutral pH, which has potent antioxidant ability capable of neutralizes and reverses the oxidizing effects of bleaching agents in dental structure [5,6,10].

It seems that SA allows free radical polymerization of the adhesive to continue without premature interruption thereby reversing the compromised bonding [5]. However, there are controversial data about the effect of different concentrations and the application protocol of SA [5-36] (Table 1) Therefore, the aim of this review article was to summarize and discuss whether AS effectively reverses the decrease in bond strength to the bleached teeth.

Methods

Data sources

An electronic search was performed in PubMed. There was no language or date restriction

Data selection

All original articles or reviews listed in PubMed (search term: sodium ascorbate OR antioxidant) AND (bleaching OR hydrogen peroxide OR carbamide peroxide) were included in the review.

Results and Discussion

Sodium Ascorbate Presentation

Studies that analysed different presentations of SA (solution or hydrogel) founded no difference between the effectiveness of both forms to overcome the lower bond strength of bleached teeth [10,13,15]. However, SA hydrogel must be applied for a longer time period due to its low penetration capability when compared to the solution [14]. The additives within hydrogel may reduce the efficacy of the material, thus decreasing the ascorbate diffusivity [10,14,28]. Conversely, it was reported that when chemical substances of SA are converted into hydrogel form, their drug releases rates are much slower than in the solution form, and their efficiency periods could be much longer [12]. Moreover, the application of SA solution is more difficult because its flowability and should be applied several times prior to bonding [10,17]. Furthermore, the hydrogel form can be loaded in the same tray used for home bleaching and

Table 1. Description of *in vitro* studies using sodium ascorbate to revert the decreases in bond strength after bleaching

First author, year	Test modality	SA concentration and form	SA application time	Substrate	Type and concentration of Bleaching agent	Results
Lai, 2002[5]	Microtensile bond strength	10% solution	3 h	Enamel	10% CP (8 h)	Effective
Kaya, 2003[6]	Shear bond strength	10% solution	10 min (with continuous agitation)	Dentin	35% PH gel (3 applications of 10 min); 35% HP solution (6 applications of 5 min)	Effective
Türkün, 2004[7]	Thermocycling and shear bond strength	10% solution	10 min (with continuous agitation)	Enamel	10%, 16%, and 22% CP (8 h/d for 1 week)	Effective
Bulut, 2005[8]	Shear bond strength	10% solution	10 min (with continuous agitation)	Enamel/bracket	10% CP (8 h/d for 1 week)	Effective
Bulut, 2006[9]	Shear bond strength	10% solution	10 min (with continuous agitation)	Enamel/bracket	10% CP (8 h/d for 1 week)	Effective
Kimyai, 2006[10]	Shear bond strength	10% solution/10% and 20% hydrogel	3 h (both forms)	Enamel	10% CP (8 h)	Both concentrations and forms were effective
Gökçe, 2008[11]	Thermocycling and shear bond strength	10% solution	10 min (with continuous agitation)	Enamel/resin luting cement	10% CP (8 h/d for 1 week)	Effective
Kaya, 2008[12]	Shear bond strength	10% hydrogel	10, 60, 120, 240, and 480 min	Enamel	10% CP (8 h for 1 week)	Effective if applied for at least 60 min
Kimyai, 2008[13]	Shear bond strength	10% solution/ 10% and 20% hydrogel	3 h (both forms)	Dentin	10% CP (8 h)	Both concentrations and forms were effective

(Continue)

Table 1 (Conclusion)

First author, year	Test modality	SA concentration and form	SA application time	Substrate	Type and concentration of Bleaching agent	Results
Türkün, 2009[14]	Thermocycling and shear bond strength	10% solution/ 10%, 5% and 2.5% hydrogel	10 min (hydrogel) 2 h (solution)	Enamel	10% CP (8 h/d for 1 week)	Effective only at 10% concentration; both forms
Kimyai, 2010[15]	Shear bond strength	10% solution/10% hydrogel	10 min, 3 h	Enamel/bracket	10% CP (8 h/d for 1 week)	Effective only after 3 h application; both forms
Uysal, 2010[16]	Shear bond strength	10% solution	10 min (with continuous agitation)	Enamel/bracket	16% CP (4 d period for 2 times)	Effective
Dabas, 2011[17]	Shear bond strength	10%/20% hydrogel	30, 60, and 120 min	Enamel	17% CP (8 h/d for 5 d)	Effective
Daneshi-sani, 2011[18]	Shear bond strength	10% hydrogel	10 min (with continuous agitation)	Enamel/resin-modified glass ionomer	9.5% HP (6 h/d for 1 week)	Effective
Feiz, 2011[19]	Shear bond strength	10% hydrogel	40 h	Dentin	35% HP (5 d – walking bleach technique)	Effective
Lima, 2011[20]	Microshear bond strength	10%	10 min	Enamel and dentin	16% CP (6 h/d for 14 d); 35% HP (3 applications of 15 min)	Effective
Khoroushi, 2011[21]	Shear bond strength	10% hydrogel	6 h	Enamel	20% CP (6 h/d for 5 d)	Effective when two-step and three etch-and-rinse bonding system were used
Mazaheri, 2011[22]	Shear bond strength	10% hydrogel	10 h	Enamel/glass ionomer	9.5% HP (6 h/d for 5 d)	Effective
Silva, 2011[23]	Microtensile bond strength	10% solution	10 min	Enamel	38% HP (3 applications of 15 min)	Effective
Vidhya, 2011[24]	Shear bond strength	10% solution	10 min	Enamel	38% HP (10 min)	Effective
Khoroushi, 2012[25]	Shear bond strength	10% hydrogel	6 h	Dentin	20% CP (5 h/d for 5 d)	Effective when etch-and-rinse and self-etch bonding systems were used
Akin, 2013[26]	Thermocycling and shear bond strength	10% solution	10 min (with continuous agitation)	Enamel/bracket	35% HP (3 cycles of 15 min)	Effective
Aksakalli, 2013[27]	Shear bond strength	10% solution	10 min (with continuous agitation)	Enamel/bracket	40% HP (20 min)	Effective
Briso, 2013[28]	Microtensile bond strength	10% solution	10 min	Dentin	10% CP (4 h/d); 35% HP – 3 applications per section/ 3 sections with 7-d interval)	Effective only after 10% CP
Güler, 2013[29]	Microtensile bond strength	10% solution	10 min	Enamel	16% CP (8 h/d for 1 week); 35% HP (30 min/twice a day with 3-d intervals)	Effective
Thapa, 2013[30]	Shear bond strength	10%/25% solution	10 min	Enamel	10% CP (8 h/d for 1 week)	Effective
Yoon, 2013[31]	Microshear bond strength	10% solution	30 s, 1 min, and 2 min	Dentin	Sodium perborate (2 g/1 mL) – 7 d	Bleaching and SA did not interfere
Torres, 2006[32]	Shear bond strength	10% solution	20 min	Enamel	35% HP (3 applications of 10 min)	Ineffective
Sasaki, 2009[33]	Shear bond strength	10% solution/10% hydrogel	2 h	Enamel/dentin	10% CP (2 h/d for 2 weeks)	Ineffective
May, 2010[34]	Shear bond strength	10% solution	10 min total over two applications	Dentin/ceramic	35% CP	Ineffective
Tabatabaei, 2011[35]	Microshear bond strength	10% solution	5 min and 10 min	Dentin	35% CP (45 min)	Ineffective
Berger, 2013[36]	Microtensile bond strength	10% hydrogel	1 h	Enamel	10% CP (6 h/d for 2 weeks)	Ineffective

SA – sodium ascorbate; HP – hydrogen peroxide; CP – carbamide peroxide.

applied by the patients, thus reducing the chair time [5,14]. Up to know there is no information about the composition of the antioxidants, and the unstable antioxidant compounds in both forms, limiting their use to only a few hours after manipulation [28,37].

Sodium ascorbate concentration

The antioxidant concentration, form, and duration of application have been considered important factors for improving bonding strength after bleaching [6,13,20,33]. It has been suggested that SA at concentrations below 10% have no effective neutralize ability [14]. While, other studies founded no statistically significant difference among concentrations above 10% (20%, 25% or 35%, on solution or gel form) [10,17,30]. Therefore, 10% SA might be as effective as high concentrations in neutralizing the oxidizing effects of bleaching and increasing bond strengths. The 10% SA has been the most frequently concentration used in studies**,** being considered adequate for clinical application in solution form [5-15,28,30,31,33,36].

Sodium ascorbate versus bleaching agent type

Most studies, which tested the effectiveness of AS in reversing compromised bond strengths, used carbamide peroxide at low concentrations [5,7-16,20,21,25,28-30,33]. It is possible that SA was more effective in teeth bleached with carbamide peroxide due the hydrogen peroxide releases a high oxygen concentration [37]. 10% carbamide peroxide releases 3% hydrogen peroxide and 7% urea [38]. This is 10 times lower than the 35% concentration and thus could probably result in different amounts of SA being required to balance the reaction. So, the adversely effect of bleaching treatment is directly related to exposure time of bleaching agent [41]. It was suggest that the amount of residual oxygen is proportional to the reduction in bond strength, as well as the reduced length and frequency of resin tags in the bleached substrate [28]. Also, it has been reported that when SA was continuously refreshed and the enamel surface was agitated it can enhance the antioxidant effect on the bleached substrate [8,34]. Freire et al. [40] recommended application of 25% SA solution for 5 minutes when the 35% hydrogen peroxide was used for bleached teeth. Perhaps, the different kinetics degradation of bleaching agents type may influence the antioxidant ability of SA. Studies that did not observe the effectiveness of AS used high concentrations of peroxide or long time exposure of bleaching agent [32-36].

Sodium ascorbate application time

The time required for complete recovery to nonbleached bond strength levels have been reported to range from 1 minute to 40 hours. It has been reported that the number of applications of the antioxidizing agent is more important than the time of contact with the tooth structure due the reaction of SA peaks in about one minute, after which the reaction decreases substantially [41]. Others suggested that the antioxidant must remain in contact with the bleached substrate for at least one-third of the bleaching treatment period, fact that often prevents the clinical use [5]. Freire et al. [41] observed that 2 one-minute applications of 35% SA immediately after bleaching eliminated residual peroxide. When the reaction kinetics of 35% hydrogen peroxide and SA were analysed, it was observed that a longer application time for SA had no influence on the effectiveness of the reaction, and that 5 minutes is sufficiently for apply this antioxidant [40].

Effects of sodium ascorbate in other dental properties

It is believed that its the use of SA is not harmful to the oral cavity [5,6]. However, few studies are reported in the literature about the interaction of SA with the soft and hard tissues of the oral environment. May et al. [34] applied the 10% SA on unbleached dentin to verify other possible effects besides reducing the residual bleaching agent, and observed that application of SA was not interfere with unbleached teeth, indicating that this substance only acts by reducing the residual free radicals on the bleached structure. On other hand, Briso et al. [28] verified that the use of 10% SA alone led to limited resin tags and hybrid layer, although their formations remained continuous and homogeneous across the adhesive interface. However, this finding not decreases the microtensile bond strength. When the 10% SA was use immediately after enamel bleaching, the hybrid layer and resin tags length were increased, but not as great as untreated enamel. Oskoee et al. [39] verified that 35% carbamide peroxide followed by application of 10% SA did not have any detrimental effect on enamel microhardness. Regarding the surface topography, SEM analysis showed a network of SA adsorbed to the bleached enamel surface and lost integrity of enamel rods due to bleaching process [41]. Kimyai et al. [15] reported that antioxidant treatments failed to improve the adhesive remnant index following bleaching. Also, SA is capable of protecting the pulp cells against the toxic effects of sub-products released from the bleaching agent [42]. When the antioxidant was applied before bleaching, less damage to the odontoblast-like cells MDPC-23 was found, suggesting the SA solution may protect against the deleterious effect of hydrogen peroxide [43]. Others studies have reported that SA can also promote resistance to fracture of teeth after internal bleaching [44] reduce microleakage [45,46,47], and restored the decrease in the Ca/P ratio after bleaching [48]. Khoroushi et al. [44] reported that the SA hydrogel gradually attains a yellowish color, and after seven days, it becomes dark yellow to orange [44]. If this gel remains for a long time in contact with the dental substrate, it can reverse the bleaching outcome [44].

Others factors that can influence the SA effectiveness on dental bond strength

Beyond the different protocols for SA application, other factors may have contributed to the different results when using this antioxidant agent. The antioxidant durability can be affected by storage conditions (temperature, time, light,

exposure) [49]. Also, the loading method can influence relative strength measurements [8,15]. Further, the dentinal characteristics such as thickness, hardness and calcium concentration might influence the bond strength when tested in dentin [50]. It seems that the method of application, the chemical composition and the viscosity of the adhesives systems could affect the antioxidant as a reducing agent, since the thickness of the oxygen-inhibited layer depends on these characteristics [25]. The different adhesives demonstrated different degrees of reversed bond strength subsequent to applying the SA and the three-step etch&rinse demonstrated higher SBS after antioxidant application while the one-step self-etch presented significantly lower bond strength even after SA application [21].

In vivo studies about sodium ascorbate

To our knowledge, there is only one study in the literature that reported the use of SA *in vivo*. Garcia et al. [51] used in a female patient a combination of in-office and at-home bleaching protocols. After the end of bleaching treatment, 10% SA hydrogel was applied inside the at-home bleaching tray for 1 hour. Following this time, the restorative procedure was carried out with a conventional two-step adhesive system and a resin composite. The one-year evaluation observed that the restorations remained stable, and no signs of pulpal or periodontal disease were found.

The most *in vitro* studies presented in the literature cannot reproduce the clinical situation in bleaching treatments. It is difficult to compare the results of researches due to different application protocols of bleaching agent and SA. Further studies should be conducted to verify the clinical applicability and the effect of SA in other dental properties.

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