ORIGINAL RESEARCH

Is α-Tocopherol or Sodium Ascorbate Effective as Antioxidant on Fracture Resistance of Bleached Teeth?

Thais P Leandrin[1], Cristiane M Alencar[2], Keli R Victorino[3], Andréa AR Dantas[4], Reinaldo O Lima[5], Júlia C Martins[6], Joissi F Zaniboni[7], Edson A de Campos[8], Milton C Kuga[9]

Abstract

Aim: To evaluate the effect of two antioxidant formulations (sodium ascorbate and α-tocopherol) on fracture resistance of endodontically treated teeth.

Materials and methods: Sixty human premolars were endodontically treated and divided into six groups (n = 10): G1 (negative control)—unbleached and restored with composite resin; G2 (positive control)—bleached in three sessions, using hydrogen peroxide (15 H_2O_2) plus titanium dioxide (TiO_2) nanoparticles, photoactivated by LED laser system and restored with composite resin; G3—bleaching similar to G2, after the use of 10% sodium ascorbate gel for 24 hours and restored with composite resin; G4—similar to G3, but with the use of 10% sodium ascorbate solution and restored with composite resin; G5 and G6—similar to G3, but with the use of 10% α-tocopherol in alcohol or carbopol, respectively, and was also restored. A mechanical fracture resistance test was performed and the Kruskal-Wallis test was used to evaluate the results ($\alpha = 0.05$).

Results: No statistical difference was observed in fracture resistance between groups ($p > 0.05$). Regarding the antioxidant and pharmaceutical formulation applied, no statistical difference was detected in any comparison ($p > 0.05$). The frequency of fractures considered favorable was higher in G1 and G3 compared to the other groups.

Conclusion: The endodontically treated teeth bleached with 15 H_2O_2 plus TiO_2 nanoparticles and photoactivated with the LED laser did not decrease the fracture resistance and the use of sodium ascorbate or α-tocopherol did not increase the crown fracture resistance.

Clinical significance: The literature reports a significant reduction in the bond strength of restorations on the bleached dentin. Therefore, the use of antioxidant agents may have a promising effect on fracture resistance of endodontically treated teeth.

Keywords: α-Tocopherol, Antioxidants, Hydrogen peroxide, Sodium ascorbate, Tooth bleaching.

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Introduction

Intracoronal bleaching is a conservative procedure for managing discolored endodontically treated teeth.[1,2] Teeth discoloration varies in etiology and can be classified as intrinsic, extrinsic, or a combination of both. The principal causes of intrinsic discolorations are (1) systemic causes, such as drug-related (tetracycline), metabolic, and/or genetic disorders; (2) local causes, such as pulp necrosis, intrapulpal hemorrhage, pulp tissue remnants after endodontic treatment, endodontic materials, and aging.[1,3]

The mechanism of action of bleaching materials is based on oxidation reactions on the dental tissue. The products of these reactions are free radicals of oxygen and water, after the breakdown of the pigment macromolecules.[4] Hydroxyl or perhydroxyl free radicals can interfere with the polymerization of the restorative material and the penetration of the adhesive system in dentin fracture resistance.[5,6] These free radicals bind to hydroxyapatite and produce apatite peroxide. This product is able to degrade hydroxyapatite Ca^+ ions and phosphate.[7]

Photoactivation or heat can facilitate these reactions and accelerate the bleaching process.[8,9] New technologies provided the light emitted diode (LED) and the laser equipment,[10] although their clinical effectiveness is questionable. However, because this light is relatively inefficient for heating a transparent hydrogen peroxide gel, pigments are incorporated into the gels to absorb as much of the light.[11]

Titanium dioxide (TiO_2) is a light-colored pigment and inorganic composition with a high reflectance capacity. Although TiO_2 has the capacity to scatter light in adjacent areas due to refraction and diffraction properties, the particle size used may interfere in the absorption of the light, reducing the diffusion of light in the bleaching gel, thus hindering the photocatalysis.[10] In order to solve this problem, the incorporation of TiO_2 nanoparticles into the hydrogen peroxide bleaching gel was recently proposed. However, nothing has been evaluated yet regarding the bleaching efficiency or its effects on crown fracture resistance.

Although several studies have shown a significant reduction in the bond strength of restorative materials for the dentin after dental bleaching,[12,13] there is uncertainty about this issue regarding endodontically treated patients.[6,14–17] These deleterious effects have been attributed to the residual free radicals of oxygen

[1–9]Department of Restorative Dentistry, Araraquara Dental School, UNESP—Univ Estadual Paulista, Araraquara, São Paulo, Brazil

Corresponding Author: Milton C Kuga, Department of Restorative Dentistry, Araraquara Dental School, UNESP—Univ Estadual Paulista, Araraquara, São Paulo, Brazil, Phone: +55 1633016396, e-mail: kuga@foar.unesp.br

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released during the bleaching procedures.[4] With the objective of neutralizing these free radicals, the use of antioxidants before the final composite restoration has been proposed.[2,18,19]

The application of sodium ascorbate to the pulp chamber may favor immediate restoration of the tooth after nonvital bleaching. In addition, it has been previously reported that sodium ascorbate is capable of removing oxygen radicals.[2] α-Tocopherol, an antioxidant in the lipid phase of the human body, has been recently suggested for improving composite bonding following bleaching. The beneficial effect of α-tocopherol solution is attributed, in addition to its antioxidant effect, to its alcoholic solvent.[19] Sasaki et al.[4] evaluated the effects of sodium ascorbate and 10% α-tocopherol in the form of gel and solution on the bond strength of the previously cleaned enamel and dentin and concluded that α-tocopherol reduced the accumulation of oxygen on the surface of the enamel. In contrast, Khoroushi et al.[20] observed that the 38% hydrogen peroxide whitening procedure had a negative effect on the adhesive strength of endodontically treated teeth, but the intracoronal use of 10% sodium ascorbate was able to reverse this damage.

An antioxidant can be found in gel or solution formulations.[4] The formulation choice is related to the clinical practicality, since the use of gel formulations should be more practical for clinical use. On the other hand, the presence of alcohol in the antioxidant formulation may contribute to better diffusion of the adhesive system into the dentin.[21] However, there is no study comparing the different formulations after bleaching procedures.

The aim of this study was to evaluate the effect of antioxidant agents (10% sodium ascorbate or 10% α-tocopherol) on fracture resistance of teeth treated endodontically and subjected to internal bleaching with hydrogen peroxide (15% H_2O_2). The null hypothesis is: There is no impact of different bleaching protocols on fracture resistance of endodontically treated teeth.

Materials and Methods

This study was approved by the Ethics and Research Committee on Human Beings at Universidade Estadual Paulista—UNESP, School of Dentistry of Araraquara. Sixty human premolars were extracted for orthodontic reasons at the Faculty of Dentistry of Araraquara, UNESP. The teeth were obtained from patients aged 18–25 and stored in 0.1% thymol at 4°C.

The specimens used in this study were the teeth treated endodontically. For root canal treatment, ProTaper rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) up to the F2 instrument were used. A 2.5% sodium hypochlorite (chlorine, Rio Preto, SP, BR) was used to irrigate the canal. In sequence, the root canals were filled with 17% EDTA (Biodinâmica, Ibiporã, PR, BR) and dried. The single cone technique for canal filling was performed using the AH Plus sealer (Dentsply DeTrey, Konstanz, Germany). The quality of the filling was assessed using radiographs.

About 2 mm of the gutta-percha was removed from the cervical third of the root canal using heated instruments (Touch Heat 5004; Sybron Endo, Orange, CA, USA). A cervical plug was made with the glass ionomer cement (Maxxion, FGM, Joinville, SC, Brazil). The samples were inserted the polyester-based resin (Maxi Rubber, São Paulo, SP, Brazil) until the cement-enamel junction (CEJ) and were stored for 24 hours. After the storage period, specimens were randomized into six groups (n = 10): G1 (negative control group): not cleared, only restored. Conditioning was carried out with 37% phosphoric acid (Condac, FGM, Joinville, SC, Brazil) for 15 seconds and then washed with water for 10 seconds. After that, an adhesive system was applied according to the manufacturer's recommendations (Adper Scotchbond Multi-Purpose; 3M ESPE, St Paul, MN, USA) and light-cured for 20 seconds using a 1000 mW/cm^2 light (LED OrtholuxTM; 3M Unitek, Sumaré, SP, Brazil) for 20 seconds. The incremental restorative technique (1.0 mm thick per increment) with the composite resin (Z100, 3M ESPE, St. Paul, MN, USA) was used. Each increment of the restorative material was polymerized (Elipar Freelight 2, 3M ESPE, St. Paul, MN, USA) for 20 seconds until the pulp chamber was completely filled.

For G2 (positive control group): Bleaching with 15% H_2O_2 containing TiO_2 (Lase Lite 15%, DMC, São Carlos, SP, BR) and restored. The bleaching gel was handled and applied according to the manufacturer's recommendations: intracoronal application and on the buccal and lingual surfaces. After application, the bleaching gel was photoactivated by an LED laser equipment (Whitening laser II, DMC, São Carlos, SP, BR) for 3 minutes. The clarifying material was removed and reapplied again under the same conditions. Three identical bleaching sessions were carried out with an interval of 7 days. After each session, the coronal cavity was sealed with a temporary material (Coltosol, Vigodente SA, Rio de Janeiro, RJ, BR). The samples were kept in artificial saliva (Faculty of Pharmaceutical Sciences of Ribeirão Preto—USP, Ribeirão Preto, SP, BR) during the study. After the three bleaching sessions, the crowns were restored in the same way as G1.

For G3: Lightening performed similar to the G2 group, followed by the application of 10% sodium ascorbate. After intracoronal bleaching, the pulp chamber was filled with 10% sodium ascorbate for 24 hours (Aphoticário, Araçatuba, SP, Brazil). Then, the pulp chamber was washed with distilled water, dried, and restored as previously described in G1.

For G4: Bleaching similar to G2 and 10% sodium ascorbate solution. After intracoronal bleaching, the pulp chamber was filled with 10% sodium ascorbate for 24 hours (Aphoticário, Araçatuba, SP, Brazil).

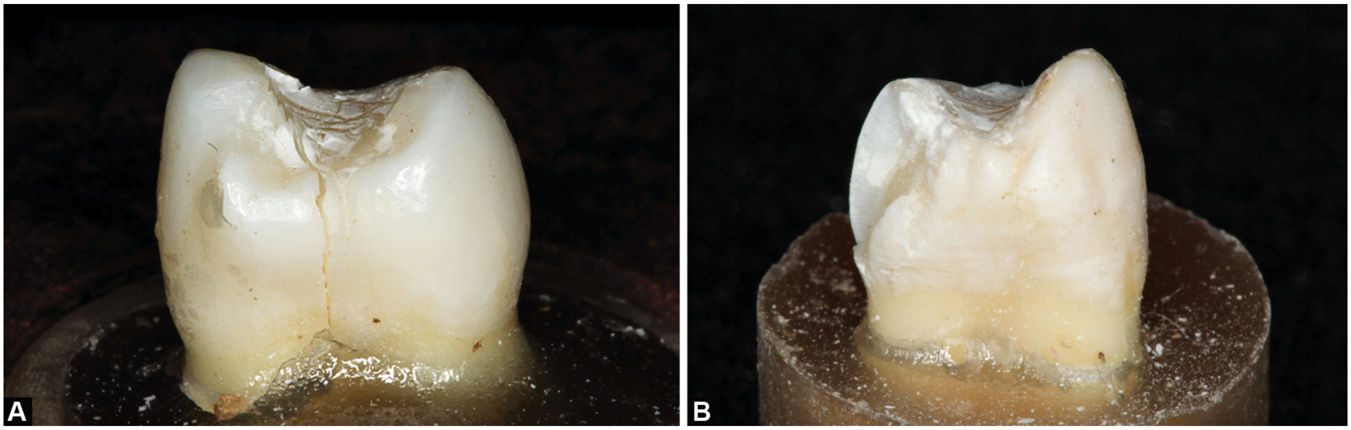
G5 and G6 were like G3, but using α-tocopherol (Aphoticário, Araçatuba, SP, Brazil) in alcohol or in carbopol (Aphoticário, Araçatuba, SP, Brazil), respectively.

The application time of the antioxidants (10% sodium ascorbate and α-tocopherol) was 24 hours, according to Khoroushi et al.[20] After 24 hours of tooth restoration, samples were submitted to axial fracture strength testing by an electromechanical machine (EMIC DL 2000, São José dos Pinhais, PR, BR) at a compressive load and a cross-head speed of 0.5 mm/minute. The fracture force was measured in Newtons (N). The fracture pattern was named in two categories: Type I (favorable fracture)—fractures that stopped more than 1 mm coronal to the CEJ and type 2 (unfavorable fractures)—fractures that stopped less than 1 mm coronal to the CEJ.[22] Figure 1 shows the fracture patterns in teeth submitted to different bleaching and antioxidant protocols.

The sample data were submitted to the Shapiro-Wilk test to establish the nonexistence of normal distribution. The results were analyzed by the Kruskal-Wallis test ($\alpha = 5\%$). The BioEstat 5.0 software (UFPa, Belém, Pará, Brazil) was used.

Results

The results of the fracture resistance of the groups are shown in Table 1. The fracture resistance of the groups is shown in Table 1. There was no statistical difference in fracture resistance between the groups studied ($p > 0.05$). The respective medians of the fracture



Figs 1A and B: Fracture patterns in teeth submitted to different bleaching and antioxidants protocols. (A) Favorable; (B) Unfavorable

Table 1: Median values, first and third quartile, and minimum and maximum values (in N) of the groups

Groups	*Median*	*Q1–Q3*	*Min–Max*
G1	785.16	645.09–900.68	269.87–1567.96
G2	704.69	553.07–915.33	136.64–1494.35
G3	696.74	629.87–833.04	441.95–1058.03
G4	577.40	438.88–1203.69	287.76–1487.54
G5	766.55	606.66–837.90	372.80–930.07
G6	789.74	607.83–876.79	299.30–1175.07

*No statistical significant differences between groups ($p > 0.05$). G1: unbleached; G2: bleached and restored with composite resin; G3: bleached and 10% sodium ascorbate gel; G4: bleached and 10% sodium ascorbate solution; G5: bleached and 10% α-tocopherol gel; and G6: bleached and 10% α-tocopherol solution

Table 2: Failure mode in number and percentages of the studied groups

Groups	*n*	*Favorable*	*Unfavorable*
G1	10	7 (70.0)	3 (30.0)
G2	10	3 (30.0)	7 (70.0)
G3	10	7 (70.0)	3 (30.0)
G4	10	6 (60.0)	4 (40.0)
G5	10	5 (50.0)	5 (50.0)
G6	10	6 (60.0)	4 (40.0)

G1, unbleached; G2, bleached and restored with composite resin; G3, bleached and 10% sodium ascorbate gel; G4, bleached and 10% sodium ascorbate solution; G5, bleached and 10% α-tocopherol gel; G6, bleached and 10% α-tocopherol solution

resistance (in N) showed by groups were: G1 (785.16), G2 (704.69), G3 (696.74), G4 (577.40), G5 (766 55), and G6 (789.74).

Regarding the failure mode, in G1 and G3, the highest incidence of favorable fractures was observed. The highest incidence of unfavorable fractures was observed for G2. Table 2 shows the results of the failure mode in number and percentage of cases.

Discussion

Regarding the use of 10% sodium ascorbate and α-tocopherol, both in gel and in solution formulation, there were no effects on the fracture resistance of tooth crowns submitted to an internal bleaching protocol with 15% hydrogen peroxide with titanium dioxide nanoparticles photoactivated by an LED laser system. The null hypothesis was accepted.

The endodontically treated teeth bleaching procedures using peroxides and several methods are relatively effective and more conservative than any prosthetic procedures. However, the reduction of crown fractures resistance is the most frequent complication after bleaching teeth.[6,17]

Poor standardization in specimen alignment at the time of testing has been reported in previous studies in a clinical manner.[16,23] In the present study, an axial force incidence was applied at a 135° angle with the long axis of the root, in similar conditions as described by previous studies.[14,20] Despite the incidence of force at the 135° angle with the long axis of the root, it is an approximate value of the inter-incisal angle formed between the maxillary and mandibular incisors.[16,17] In this situation, there is a high incidence of crown fracture only in the CEJ.[6,15]

The combination of in-office and at-home bleaching procedures was avoided, because the aim of this study was the exclusive assessment of the in-office bleaching protocol using 15% hydrogen peroxide with TiO_2 nanoparticles, photoactivated by LED laser and the effects of sodium ascorbate and α-tocopherol on the crown fracture resistance. The experimental groups (G1–G6) were compared with the negative (G1) and positive (G2) control groups, but there was no comparison with the intact teeth, because it is known that these specimens present higher fracture resistance than endodontically treated teeth.[16]

Some factors can have negative effects on the crown fracture resistance after intracoronal bleaching procedures, such as the hydrogen peroxide concentration, number of bleaching sessions, time of applications, interval of applications, and final restoration procedure.[6,14–17] In the present study, the experimental groups showed a statistically similar crown fracture resistance to the control groups. However, the hydrogen peroxide utilized was in a 15% concentration and only applied in three bleaching sessions, while in other studies that showed a significant decrease in the fracture resistance, hydrogen peroxide in a 38% concentration was utilized in several sessions.[17,20] The combination of a high hydrogen peroxide concentration with long-term dental bleaching results in a reduction of the dentin fracture resistance.[24,25] On the other hand, there is no difference when assessed immediately after a single bleaching session.[15]

Low-concentration hydrogen peroxide containing TiO_2 is used as a bleaching agent. Bleaching is enhanced by the production of oxidative hydroxyl radicals via titanium dioxide photocatalysis after irradiation with violet or blue light, and its bleaching effects are similar to conventional high-concentration hydrogen peroxide.[26]

However, Caneppele et al.[10] detected TiO_2 in 35% hydrogen peroxide and photoactivation did not interfere with the final results of the bleaching.

Since the TiO_2 nanoparticles and photoactivation with a LED laser did not interfere with the crown fracture resistance, it is possible that the light source used in this study was not efficient. The LED light acts by absorbing the complementary color of the bleaching gel, with a complementary color range to blue light. In light of this, the inefficiency of the lux LED could be explained by the deficient interaction between the LED light and the white-colored gel.[10]

In relation to the antioxidants, Khoroushi et al.[20] observed that the use of 10% sodium ascorbate was effective on the bond strength of subjects undergoing internal whitening. However, the use of 10% sodium ascorbate or α-tocopherol did not change the fracture resistance of the crown.[27] The low concentration of hydrogen peroxide, the physical properties of the TiO_2 nanoparticles, and the light source used can have influences in the final results.

In this study, antioxidants have been used for 24 hours and immediately after bleaching treatment. Both sodium ascorbate as α-tocopherol exerted no effect, positive or negative, on the fracture resistance of the dental crown. This result may have been influenced by application time, since Lai et al.[28] encouraged the use of antioxidant material in one-third of the total whitening time. The bleaching time in the present study was 54 minutes. Therefore, it is possible that the application time was excessively long and interfered with the results. There is still a need for further studies that examine the correct time to use these antioxidants. However, in this study, the recommendations proposed by Khoroushi et al. were followed.[20]

Perdigão et al.[29] observed that the presence of residual oxygen has a negative impact on the adhesive strength of bleached teeth. On the other hand, Sasaki et al.[4] evaluated the efficiency of sodium ascorbate to α-tocopherol in the shear strength of the tooth submitted to bleaching with 10% carbamide peroxide. It was concluded that these antioxidants were not able to eliminate the presence of residual oxygen on the whitened dentin surface. Probably, both antioxidants used in the present study were unable to totally neutralize the oxygen and hydroxyl or perhydroxyl ions that were released during the bleaching treatment.[30]

The final composite resin restoration may have influenced the similar results between the groups. Azevedo et al.[16] observed that teeth restored with the composite resin after intracoronal bleaching presented a similar fracture resistance to teeth without any bleaching procedure.

Therefore, intracoronal use of 10% sodium ascorbate or α-tocopherol after teeth bleaching using 15% hydrogen peroxide with TiO_2 nanoparticles and photoactivated with a LED laser did not alter the crown fracture resistance. Further studies should be conducted to evaluate the different antioxidant application times in endodontically treated teeth bleaching using several hydrogen peroxide concentrations and dental bleaching procedures.

Conclusion and Clinical Significance

The endodontically treated teeth bleached with 15 H_2O_2 plus TiO_2 nanoparticles and photoactivated with the LED-laser did not decrease the fracture resistance and the use of sodium ascorbate or α-tocopherol did not increase the crown fracture resistance.

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