The effect of natural antioxidants on bond strength of composite resin to tooth structure post internal bleaching

Pengaruh antioksidan alami terhadap kekuatan ikatan resin komposit dengan struktur gigi pasca pemutihan internal

Juni Jekti Nugroho, Febrianty Alexes Siampa, Hafsah Katu
Department of Conservative Dentistry
Faculty of Dentistry, Hasanuddin University
Makassar, Indonesia.
Corresponding author: **Juni Jekti Nugroho**, e-mail: **jektijuni@yahoo.co.id**

ABSTRACT
Internal bleaching is a non-vital bleaching tooth method performed after endodontic treatment of discolored teeth, by the application of strong oxidator agents in pulp chamber. Internal bleaching agents can have adverse effects, one of which is the reduced bond strength of the composite resin with the tooth structure. There are various types of antioxidants that can improve bond strength after internal bleaching procedures, generally synthetic antioxidant ingredients. Besides that, many antioxidants from natural plant extracts have been developed, such as green tea extract, pine bark, rosemary, pomegranate peel and grape seed. The objective of this article is to improve knowledge about antioxidant materials that can be used to increase the bond strength of composite resin on the tooth structure after internal bleaching. The use of bleaching agents has been shown to reduce the bond strength of composite resin after internal bleaching. Researchers have focus on plant extracts to develop a non-toxic, biocompatible and effective antioxidant protocol which can be safely applied to oxidized tooth structures. It is concluded that there are various kinds of antioxidants materials from natural plant extracts which can be used in dentistry to increase the bond strength of composite resin on the tooth structure after internal bleaching.
Keywords: internal bleaching, composite resin bond strength, tooth structure, antioxidants

ABSTRAK
Bleaching internal adalah metode pemutihan gigi non vital yang dilakukan setelah perawatan endodontik pada gigi yang mengalami diskolorasi, dengan cara mengaplikasikan agen oksidator kuat dalam kamar pulpa. Agen bleaching internal dapat memberikan efek yang merugikan, salah satunya adalah berkurangnya kekuatan ikatan resin komposit dengan struktur gigi. Terdapat berbagai jenis antioksidan yang dapat meningkatkan kekuatan ikatan setelah prosedur bleaching internal, umumnya bahan antioksidan sintetik. Disamping itu, banyak antioksidan dari ekstrak tanaman alami yang telah dikembangkan, seperti ekstrak teh hijau, kulit pinus, rosemary, kulit delima dan biji anggur. Tujuan dari artikel ini adalah untuk meningkatkan pengetahuan tentang bahan antioksidan yang dapat digunakan untuk meningkatkan kekuatan ikatan resin komposit pada struktur gigi setelah bleaching internal. Bahan bleach terbukti mengurangi kekuatan ikatan resin komposit pasca bleaching internal. Ekstrak tanaman telah dikembangkan untuk protokol antioksidan yang tidak beracun, biokompatibel, dan efektif yang dapat diaplikasikan pada struktur gigi yang teroksidasi. Disimpulkan bahwa terdapat berbagai bahan antioksidan dari ekstrak tumbuhan alami yang dapat digunakan dalam kedokteran gigi untuk meningkatkan kekuatan ikatan resin komposit pada struktur gigi pasca bleaching internal.
Kata kunci: bleaching internal, kekuatan ikatan resin komposit, struktur gigi, antioksidan
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INTRODUCTION

In recent decades, people have become obsessed with having an attractive smile, one of the main concerns is having bright or white teeth. Internal bleaching is a non-vital bleaching tooth method performed after endodontic treatment of discolored teeth, by applying of strong oxidator agents in pulp chamber. The right technique of IB can be a conservative treatment approach and safe for treating discolored teeth. The causes of tooth discoloration are varied and complex but are usually classified as being either intrinsic, extrinsic or internalized in nature. Stains in dentine or intrinsic discoloration often results from systemic or pulpal origin.[1,2]

Hydrogen peroxide which is used as a bleaching agent is a strong oxidizing agent. This agent is not only effective in brightening the color of teeth but can also provide side effects, such as pulpal sensitivity, changes in the tooth structure and reduced bond strength of the composite resin. The bond strength of composite resin is very important to increasing mechanical and physical properties of the restoration so that won't easily release.[3] Various theories have been proposed to explain the adverse effect of bleaching on composite resin to tooth structure. Bleaching with H_2O_2 may result adversely decrease on the microtensile bond strength (μTBS) of composite to the enamel when bonding is performed immediately after the bleaching process. Other author speculated that residual peroxide and oxygen radical in bleached teeth interfere with the polymerization of adhesive restorative material and decrease the bond strength.[1,4]

Many techniques have therefore been proposed to overcome the decrease in the bond strength caused by the bleaching of enamel such as removal of the superficial enamel layer, pretreatment of bleached enamel with alcohol, use of adhesives containing organic solvents, a post-bleaching waiting period ranging from 24 hours

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to three weeks and use antioxidants. Antioxidants have been proven in many studies to be a safe and effective solution to increase the bond strength directly after bleaching. Natural antioxidants, as well as synthetic phenolic antioxidants can effectively inhibit oxidation and have been successfully used to increase the bond strength of a composite resin to bleached enamel.[4]

There are various kinds of antioxidants that can increase bond strength after IB procedures. Commonly used are synthetic antioxidant materials, such as sodium bicarbonate and some vitamins like α-tocopherol (an active component of the vitamin E complex) and ascorbic acid are neutral, biocompatible and potent antioxidants that have the ability to reduce various oxidative compounds after IB. Besides that, many antioxidants from natural plants extract have been explored, such as green tea extract, pine bark, rosemary, pomegranate peel and grape seed.[3]

This literature review is aimed to improve knowledge about antioxidant materials that can be used to increase the bond strength of composite resin on the tooth structure after IB.

LITERATURE REVIEW

Internal bleaching (IB)

The IB is a minimally invasive, conservative, relatively simple, effective, and low-cost method in treatment of discolored endodontically treated teeth. There are several internal tooth bleaching techniques, the most common being the walking-bleach technique, first described by Spasser, in 1961. Other techniques include the thermocatalytic technique and the inside-outside technique. The walking-bleach or conventional technique consists of inserting the bleaching agents into the pulp chamber, closing the access cavity with a temporary filling, and the dentist refreshing the bleaching agents on a weekly basis until a satisfactory color is achieved. The thermocatalytic technique is similar to the conventional technique. However, the thermocatalytic method uses various heat forms in order to accelerate the release of reactive oxygen species. Currently this technique is not advisable since heat can damage periodontal tissue and lead to root resorption. The inside-outside, or combined, technique was proposed by Settembrini, and consists of simultaneous internal and external bleaching, with the use of a custom-fitted tray. In this technique, the access cavity remains open and the patient is responsible for replacing the bleaching agent daily.[5]

Agents of IB that is often used is H_2O_2, carbamide peroxide and sodium perborate. However, H_2O_2 bleaching agents have the highest concentrations that can produce more radical peroxide, so the bleaching process become faster. Generally, after the procedure internal bleaching followed by composite resin restorations to avoid recontamination bacteria.[6]

Mechanism of IB

In the bleaching process, the bleaching agent diffuses through the pores of the enamel to the dentinal tubules and a complex oxidation-reduction process occurs between bleaching agent and the tooth structure. Bleaching agent (H_2O_2) is a strong oxidizing agent which decomposes into water and oxygen for a short period to form unstable free radicals, namely hydroxyl radicals, perhydroxyl radicals, superoxide anion and nascent oxygen. These free radicals interact with pigmented organic molecules (*chromophores*) in enamel and dentin to stabilize them. This interaction will break the double bonds of the *chromophore* molecules so that they become smaller molecules through a diffusion process in the organic matrix, dissolving the inorganic structure and the protein matrix, causing a decrease in light absorption, changing the color of the teeth to be brighter. The H_2O_2 oxidizes the pigment in teeth. Yellow pigment (*xanthopterin*) is oxidized to white pigment (*leucopteris*).[2,7,8]

Effect of bleaching agent on composite restoration

The oxidation reaction of the bleaching agent, is peroxide, produces gaseous bubbles under the enamel surface (a layer that contains a lot of oxygen). This layer inhibits polymerization and prevents adequate infiltration of the bonding agent into the tooth structure, thereby affecting bond strength between the enamel and the composite resin and increasing marginal microleakage. Oxygen and free radicals build the main mechanism of action on the tooth bleaching done by penetrating through the porosity of the prism email to dentin leaving residual peroxide component. Peroxide is disturbing resin polymerization resulting in the increase of microleakage coronal and decrease the sealing ability of composite resin restorations.[6,9] It was reported that the decreases in bond strength was related to the presence of residual oxygen in the interprismatic space, which prevented adequate infiltration of the adhesive and its polymerization. It is therefore recommended to delay the restoration procedure until 3 weeks to completely remove residual peroxide.[4] However, to speed up restoration of composite resin on teeth after IB, antioxidant application is recommended.

DISCUSSION

Antioxidants are compounds that can neutralize free radicals by donating their electrons. Upon application of the antioxidants, residual oxygen and the free radicals trapped within oxidized tooth structures are removed and consequently, the compromised bonding of the resin-based restorative materials to tooth structures is improved. Immediate post-bleaching application of the an-

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tioxidants can facilitate the resin composite restorative procedures to be completed in the same session and reduce the need for another dental visit. Reactive oxygen species (ROS) is a term that includes all reactive, oxygen-containing molecules, including free radicals. Types of ROS include hydroxyl radicals, superoxide anion radicals, nitric oxide radicals, H_2O_2, and singlet oxygen. Free radicals are controlled naturally by various compounds known as antioxidants. Free radicals are electrically charged molecules unpaired electrons, so they seek and capture electrons from other substances to neutralize themselves.[6,10,11]

Antioxidant agents

Applications of antioxidant agents aims to reduce the waiting time between bleaching and restoration procedures to the disappearance of reactive oxygen species on the surface of the tooth. Antioxidant agents are effective in increasing the shear bond strength and surface tension of the composite resin restorations after bleaching because they aim to eliminate free radicals.[3] Commonly used are synthetic antioxidant agents, either type enzyme or non-enzyme has been known to include: sodium ascorbate or ascorbic acid (vitamin C), α-tocopherol (an active component of the vitamin E complex), sodium bicarbonate, superoxidase dismutase (SOD), glutathione peroxidase and catalase. But only few were found to be effective. Recently, researchers have focused on plant extracts to develop a non-toxic, biocompatible, and effective antioxidant protocol that can be safely applied to oxidized tooth structures. Antioxidants from natural plant extracts have been developed, such as green tea extract, pine bark, rosemary, pomegranate peel and grape seed.[6,11]

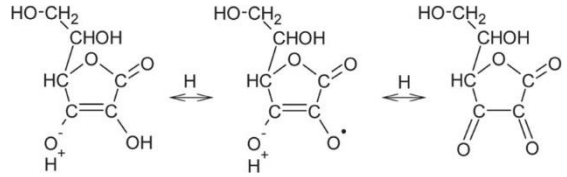

Figure 1 Oxidative mechanism of ascorbic acid representing its antioxidant properties (Source: Park JY, Kwon TY, Kim YK. Effective application duration of sodium ascorbate antioxidant in reducing microleakage of bonded composite restoration in intracoronally-bleached teeth. Restor Dent Endodont 2013; 43-7).

Sodium ascorbate/ascorbic acid (vitamin C)

Sodium ascorbate is the sodium salt of ascorbic acid and commonly used as a food additive. It is produced by the reaction of an equal amount of ascorbic acid and sodium bicarbonate using isopropanol. The double carbon bond of ascorbic acid or sodium ascorbate is capable of reducing peroxide residues by donating hydrogen and electrons to the oxidant. It has been reported that the application of sodium ascorbate antioxidant into the access cavity allows immediate composite restoration after non-vital bleaching through its ability to remove oxygen radicals (Fig. 1).[12]

Antioxidant agent sodium ascorbate can remove peroxide residue from teeth structure then increasing the bond strength between composite resin restoration and tooth structure post IB. Concentration of 10% sodium ascorbate has a pH of ± 7 and is non-toxic and thus very suitable for use on tooth structure. Sodium ascorbate is a neutral, nontoxic, and biocompatible antioxidant that when used as a 10% solution can reverse the reduced bond strength of bleached enamel.[6]

Green tea extract

Green tea is made from the Camellia sinensis plant. It contains is a rich source of flavonoids and catechins, such as epigallocatechin gallate, epigallocatechin, epicatechin gallate, epicatechin. The strong antioxidant activity of green tea has been associated with its high content of catechin and flavanol, which can neutralize free radicals by donating hydrogen from hydroxyl groups in their structure (Table 1). Green tea catechins have shown to possess the potent antioxidant activity that is several times higher than that of vitamins C and E. In recent years, the use of 10% green tea has been studied as an antioxidant material after dental bleaching. Additionally, green tea is a natural product, cheap and with an extended shelf life which could be an option for use after IB procedure.[1,11]

Pine bark extract

Pine bark extract contain *oligomeric-proanthocyanidins* that are a class of polyphenolic bioflavonoids found in fruits and vegetables which have free radical scavenging and antioxidant activity. They also have antibacterial, antiviral, anti-inflammatory, antiallergic, anticarcinogenic, and vasodilatory actions. Some in vitro studies observed that 10% pine bark extract was useful reversing the effect of free radicals on bleached enamel.[1]

Rosemary extract

Rosmarinic acid, which is a phenolic compound isolated from rosemary, was found to be more effective in improving bonding to dentin compared to sodium ascorbate protocol. Nine different phenolic compounds with antioxidant activity; *carnosol, carnosic acid, rosmanol, rosmadial, epirosmanol, isorosmanol, rosmarinidiphenol, rosmariquinone,* and *rosmarinic acid,* were isolated from rosemary extracts. Richheimer *et al*, reported that among all phenolic components of rosemary, *carnosic acid* had the greatest antioxidant potency, which was three times greater than carnosol and seven times greater than the synthetic antioxidants.[11]

Pomegranate (*Punica granatum L.*) extract

One of the fruits that is used as an antioxidant is po-

Table 1 Some free radicals and their antioxidants.[10]

Free Radicals	Antioxidants
Hydroxyl	Vit.C, glutathione, flavonoids, lipoic acid
Superoxide	Vitamin C, glutathione, flavonoids
Hydrogen peroxide	Vit.C, glutathione, beta carotene, vit.E, flavonoids, lipoic acid
Lipid peroxide	Beta carotene, vit.E, ubiquinone, flavonoids, glutathione peroxidase

megranate because it has active alkaloid compounds, flavonoids, saponins, tannins and triterpenoids. Pomegranate peel extract has been shown to be effective removing free radicals and reducing oxidative stress by donating hydrogen atoms to prevent chain reactions of converting superoxide to hydrogen superoxide. The high antioxidant activity of pomegranate extract is related to the tannin compounds potency contained. Previous studies by Mukka *et al* and Sharafeddin & Farshad have shown that the shear bond strength of composite resins increased after 5% and 10% of pomegranate peel extract was applied.[3]

Grape seed extract (*Proanthocyanidin*)

Other naturally occurring antioxidants such as grape seed extract contain *oligomeric proanthocyanidin complexes* (OPCs) that have free radical scavenging ability, which is shown to be 50 times more potent than sodium ascorbate and 20 times greater than those of vitamin E. *Proanthocyanidins* are high molecular weight polymers that comprise the monomeric flavanol, catechin and epicatechin. *Proanthocyanidins* are found in high concentrations in natural sources such as grape seed extract, pine bark extract, cranberries, lemon tree bark, and hazelnut tree leaves.

As a naturally occurring plant metabolite, it has been proven to be safe as an antioxidant in various clinical applications and dietary supplements.[13]

It is concluded that antioxidant agents applied after the bleaching procedure can bind free radicals from the effect of the bleaching procedure to minimize the occurrence of a bubble appearance, which can result in a decrease in the strength of the composite resin on teeth after IB procedure. There are various kinds of antioxidants materials from natural plant extracts which can be used in dentistry to increase the bond strength of composite resin on the tooth structure after IB.

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