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Application of Different Herbal Antioxidants on Tooth Structures for Dental Procedures: A Boon

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Abstract

After updates, people are having more awareness to dental health, various dental treatment procedures have emerged, such as tooth bleaching,Root canal treatment, dental implants, and dental restorations. However, a large number of free radicals are typically produced during the dental procedures. When the imbalance in distribution of reactive oxygen species (ROS) is induced, oxidative stress coupled with oxidative damage occurs. Oral inflammations such as those in periodontitis and pulpitis are also unavoidable. Therefore, the applications of exogenous antioxidants in oral environment have been proposed. In this article, the origin of ROS during dental procedures, the types of antioxidants, and their working mechanisms are reviewed. Additionally, antioxidants delivery in the complicated dental procedures and their feasibility for clinical applications are also covered. Finally, the importance of safety assessment of these materials and future work to take the challenge in antioxidants development are proposed for perspective.

Keywords: Antioxidants; Antioxidant Delivery; Dental Procedures; Tooth Bleaching; Dental Implants; Dental Restorations

Introduction

Since the 20th century, the prevention and treatment of oral diseases have made great progress, and the occurrence of dental caries and oral inflammation have also dropped significantly. It is reported that many oral problems are related to an imbalance of antioxidants and reactive oxygen species (ROS) in the body. In recent years, free radicals have been found to be related to the occurrence and development of dental diseases, and antioxidants have also been used in dental treatment.

Free radicals and ROS are the products of oxidative stress and have extremely oxidative properties. The main sources of free radicals in the oral environment are considered as the following: food (high fat, high calorie), alcohol and cigarettes, dental treatment (surgery, laser, ultraviolet, etc.), dental materials (adhesive, composite resin, etc.), and periodontal diseases.The antioxidant capacity in the oral environment of each person is different. Oxidative stress occurs when the body's oxidative and antioxidant capacity is imbalanced and favors oxidation, which is also the main cause of oral and dental diseases. When reacting with antioxidants, free

radicals will gain an electron and are converted into normal molecules , thereby reducing damage to the body.

Antioxidants prevent free radicals from requesting electrons from normal cells, and actively donate electrons to free radicals, thereby achieving the purpose of protecting normal cells. Antioxidants can also inactivate free radicals before they attack the body's cells, and they play a supporting role in the treatment of oral problems such as periodontitis. In addition, some researchers found that the intake of antioxidants can effectively inhibit the growth and reproduction of oral cancer cells . Antioxidants are typically divided into two types: endogenous and exogenous. Endogenous are produced by the human body, including superoxide dismutase (SOD), catalase (CAT), and reduced glutathione (GSH). Exogenous means that the human body cannot synthesize them. Commonly used exogeneous antioxidants are ascorbic acid (vitamin C), tocopherol (vitamin E), quercetin, tannic acid, and N-acetyl cysteine (NAC) [1]. This review focuses on the involvement of antioxidants in dental procedures, such as dental bleaching, and dental fillings. Types of herbal antioxidants used to treat oxidative stress induced by dental treatments and restorations are covered, From the developmental perspective, the advantages and disadvantages of current herbal antioxidants are evaluated, and future challenges are also proposed.

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 dentin leaving residual peroxide component.

Peroxide is disturbing resin polymerization resulting in the increase of microleakage coronal and decreases the sealing ability of composite resin restorations. It was reported that the decrease 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. However, to speed up restoration of composite resin on teeth after IB,antioxidant application is recommended.

Consequently, the use of antioxidant agents to reverse this side effect has been suggested to allow immediate adhesive procedures to be performed. Sodium ascorbate is a synthetic antioxidant that has been widely studied for this purpose, nevertheless, since it has been reported to be mutagenic for mammalian somatic cells and to have a short shelf-life, other natural alternatives have been researched [2].

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 [3]. Researchers have focused on natural plant extracts to develop a non-toxic, biocompatible and effective antioxidant protocol which can be safely applied to oxidized tooth structures.

Many antioxidants from plants extract have been explored, such as green tea extract, pine bark, rosemary, pomegranate peel,Aloevera,Sage and grape seed,curcumin.

Antioxidant Preparation and Application

Preparation of antioxidant solution- 1g of antioxidant powder (sodium ascorbate,aloe vera) was measured on a weighing balance. This was mixed with 10 ml of distilled water to create a 10% antioxidant solution [4].

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, epica-techin 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 (Figure 1).

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

Table 1: Some free radicals and their antioxidants.

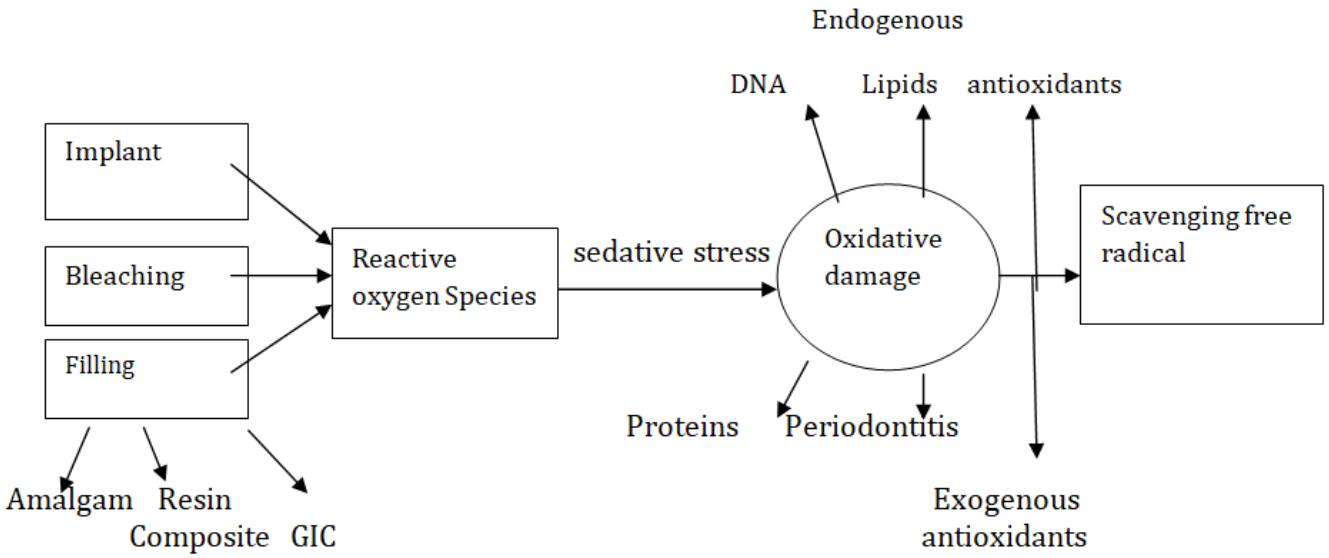

Figure 1: Schematic diagram of ROS production and clearance during dental procedures.

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

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*, *rosmarinidiphe-nol*, *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.

Pomegranate (*Punica granatum L.*) Extract

One of the fruits that is used as an antioxidant is pomegranate 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 an-tioxidant activity of pomegranate extract is related to the tannin compounds potency contained. Previous studies by Mukka et al., have shown that the shear bond strength of composite resins increased after 5% and 10% of pomegranate peel extract was applied.

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 [4].

Aloe Vera (*Aloe barbadensis miller*)

Aloe vera (*Aloe barbadensis miller*) is a short succulent herb with fleshy, green, and spiny leaves. It is readily available and easy to grow and the leaves are rich in many bioactive compounds. The leaf extracts of aloe vera is said to have potent antioxidant activity. The antioxidant effect of aloe vera is attributed to the multitude of active agents contained in aloe vera that have a synergistic effect. *Aloe barbadensis miller* is rich in polysaccharides, polyphenols, anthroquinones, indoles and alkaloids. It also contains ascorbic acid, vitamin E (tocopherol) and vitamin A. All of these compounds are known to exert antioxidant properties by neutralizing free radicals. 10% Aloe vera solution (Group E) was prepared from spray dried aloe vera (*Aloe barbadensis*) powder. Spray

dried aloe vera is prepared from the extracts of freshly harvested whole aloe leaves at a temperature of 600^{0}C to ensure that there is no loss of biological activity. This type was selected because the whole leaf extract of aloe vera plant comprises the gel and latex. Both components are rich in the active ingredients responsible for the antioxidant properties. The powder used did not have added alcohols or other solvents that could affect the findings of the study.

Sage (*Salvia Officinalis*)

Sage is an herbaceous, perennial plant of the family Lamiaceae, cultivated in South Europe, and characterized as a common, aromatic, medicinal, and food additive plant. The plant belongs to the genus Salvia containing more than 900 species, with the most representative *Salvia officinalis* L. The knowledge and use of several Salvia species (*S. officinalis*, *Salvia fruticosa*, and *Salvia pomifera*) can be dated back to the Greek Era and have a long history of culinary and effective medicinal use. *S. officinalis*, known as common or Dalmatian sage, is a perennial, evergreen sub-shrub with woody stems, grayish leaves, and blue to purplish flowers with the calyx and corolla divided into two lips. It is native to the Middle East and East Mediterranean areas, but today it has been found and cultured throughout the world. *S. officinalis* is commonly used as a diary condiment in food, hydroalcoholic tincture, and tea used in traditional and folk medicine, from ancient years, for the treatment of several disorders. Many studies have revealed a wide range of beneficial biological activities for S. officinalis, including anticancer, anti-inflammatory, antinociceptive, antioxidant, antimicrobial, antimutagenic, anti-dementia, hypoglycemic, and hypolipidemic effects. Different chemical components have been found to be responsible for these activities.[4] Numerous studies have demonstrated the capacity of S. officinalis to scavenge free radicals due to its high content of phenols and avonoids . Sage extract has been used previously in dentistry to reverse the reduction in bond strength of composite resin to bleached enamel [5-10].

Curcumin Turmeric (*haldi*), a rhizome of *Curcuma longa*, is a flavourful yellow-orange spice. Its plant is 3 feet in height and has lance-shaped leaves and spikes of yellow flowers that grow in a fleshy rhizome or in underground stem. An orange pulp contained inside the rhizome constitutes the source of turmeric medicinal powder. Components of tumeric are named curcuminoids, which include mainly curcumin (diferuloyl methane), demethoxycurcumin, and bisdemethoxycurcumin. Curcumin (diferuloylmethane) is a polyphenol derived from *Curcuma longa* plant, commonly known as turmeric. The active constituents of turmeric are the flavonoid curcumin (diferuloylmethane) and various volatile oils including tumerone, atlantone, and zingiberone. Other constituents include sugars, proteins, and resins. The best-researched active constituent is curcumin, which comprises 0.3-5.4% of raw turmeric. Curcumin has been used extensively in ayurvedic medicine for centuries, as it is nontoxic and has a variety of therapeutic properties including antioxidant, analgesic, anti-inflammatory, antiseptic activity, and anticarcinogenic activity [11].

Conclusion

Natural antioxidants offer a promising approach to protect bleached dentin from damage. By understanding their effects and mechanisms, dentists and researchers can develop innovative strategies to improve the safety and efficacy of tooth bleaching procedures.

The effects of natural antioxidants on the tooth surface after bleaching for composite resins include:

- *Improved bonding strength*: Antioxidants like vitamin C, green tea extract, and grape seed extract enhance the bonding strength between the tooth surface and composite resin.
- *Reduced oxidative stress*: Antioxidants neutralize reactive oxygen species (ROS) generated during bleaching, reducing oxidative stress and protecting the tooth surface.
- *Inhibition of collagen degradation*: Antioxidants like curcumin and green tea extract inhibit the degradation of collagen, preserving the tooth's structural integrity.
- *Increased hydrophobicity*: Antioxidants like vitamin C and grape seed extract increase the hydrophobicity of the tooth surface, improving the adhesion of composite resins.
- *Improved composite resin properties*: Antioxidants like curcumin and green tea extract improve the mechanical properties of composite resins, making them more resistant to wear and tear.
- *Reduced tooth discoloration*: Antioxidants like vitamin C and grape seed extract reduce tooth discoloration, maintaining the tooth's natural color.
- *Increased enamel hardness*: Antioxidants like fluoride and calcium increase enamel hardness, making the tooth more resistant to decay and wear.
- These effects contribute to a stronger, more durable bond between the tooth surface and composite resin, ensuring a successful and long-lasting restoration.

Limitations

Future works focused on antioxidants delivery and bioavailability assessment are highly recommended. It is also urgently necessary to conduct clinical studies, especially the long follow-up period studies in dental clinics, to further confirm the appropriate antioxidative approach for human usage. The explorations of advanced applications of antioxidants in the dental field are still underway.

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