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Antioxidants And Their Effects On Shear Bond Strength Of Bleached Enamel-A Comprehensive Review

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Abstract:
Nowadays, tooth discolouration has become a major issue. Bleaching is the greatest solution for this issue since it significantly improves the appearance of the teeth while requiring little disruption to dental structures. Nevertheless, the morphology and mineral composition of enamel are altered by these chemical agents, which has a significant impact on the orthodontic brackets' ability to bond to enamel. Thus, by preventing the oxygen radical that the bleaching methods produce, anti-oxidants have recently been developed to increase the lost bond strength of bleached enamel.
Keywords: *bleached tooth, Antioxidants, shear bond strength, enamel surface, brackets.*

INTRODUCTION: -

Not only may facial aesthetics improve our social abilities, but they also help us build healthy self-esteem[1]. Tooth yellowing has grown to be a major issue for society at large. Bleaching is the best treatment for this issue since it significantly improves tooth appearance while requiring little modification of dental structures[2]. The mechanical locking of adhesives to flaws in the tooth's enamel surface and to mechanical locks created in the orthodontic attachment's base is known as bonding[3]. Nevertheless, the morphology and mineral composition of enamel are altered by these chemical agents, which has a significant impact on the orthodontic brackets' ability to adhere to enamel. In the last several years, numerous techniques have been developed to strengthen the enamel's binding following bleaching. Chemical adhesion and/or micromechanical interlocking, which can be accomplished by surface conditioning or surface roughening, are two techniques for creating a strong bond[4]. The binding strength of enamel after bleaching can be increased by removing surface layers of enamel, using adhesives that contain organic solvents, and pre-treating with alcohol[5]. But in recent times, a number of antioxidants have been created that, by preventing the oxygen radical that the bleaching agents release, can strengthen the lost link of bleached enamel.

HISTORY OF DENTAL BLEACHING:

Numerous attempts have been made throughout the history of dental bleaching in an attempt to develop an efficient technique for whitening teeth. The first way of whitening non-vital teeth was done in 1848 using lime chloride. The most successful approach was developed by Truman in 1864 and involved the use of chlorine derived from a calcium hydrochloride and acetic acid solution. Due to Superoxol's extreme safety, most dentists started using it when it was first launched. Many more bleaching methods and products have since been developed. In the 1990s, "over-the-counter" (OTC) bleaching solutions were introduced to the US market. They were sold directly to consumers for use at home and had lower percentages of hydrogen peroxide or carbamide peroxide[6].

COMPOSITION OF BLEACHING AGENTS

(a)**Thickening agents**: Carbopol is the most commonly used thickening agent in bleaching materials. Its concentration is usually between 0.5% and 1.5%.

(b) **Carrier:** Glycerine and propylene glycol are the most commonly used carriers in commercial bleaching agents. The carrier can maintain moisture and help to dissolve other ingredients.

(c) **Surfactant and pigment dispersant**: The surfactant acts as a surface wetting agent which permits the active bleaching ingredient to diffuse and pigment dispersant keeps pigments in suspension.

(d) **Preservative:** Methyl, propylparaben, and sodium benzoate are commonly used as preservative substances. They have the ability to prevent bacterial growth in bleaching materials.

(e) **Flavouring:** Flavourings are substances used to improve the taste and the consumer acceptance of bleaching products. Examples include peppermint, spearmint, wintergreen, Sassafras, anise, and a sweetener such as saccharin.

TYPES OF DENTAL BLEACHING

1) **Vital Bleaching**

There are three fundamental approaches for bleaching vital teeth:
- In-office or power bleaching,
- At home or dentist supervised night-guard bleaching,
- Bleaching with over-the-counter (OTC) products

• **In-office bleaching** makes use of teeth-whitening chemicals at a high concentration (25–40% hydrogen peroxide). In this case, the dentist is in total control of the process and can stop it once the desired shade or effect is reached. Following the application of a rubber dam or other option to protect the soft tissues, the teeth are treated with whitening gel, and the peroxide is then further activated by heat or light in the dentist's office for approximately an hour[7]. The bleaching gel can be activated or the whitening effect accelerated by using several types of curing lamps, such as metal halide (Zoom) light, plasma arc lamp, Xe-halogen light (Luma Arch), diode lasers (both 830 and 980 nm wavelength iode lasers), or halogen curing lights. The in-office procedure may produce noticeable teeth whitening after only one treatment, but many more may be needed to achieve an optimum result[8]. (fig 1)

• **At-home or dentist-supervised night-guard bleaching** essentially uses whitening agents at low concentrations (10–20% carbamide peroxide, or 3.5–6.5% hydrogen peroxide). It is often advised to use 10% carbamide peroxide for eight hours each day and 15%–20% carbamide peroxide for three to four hours every day. Although patients administer this treatment on their own, dentists should oversee it at follow-up appointments. Using a mouth guard that is specially made and worn at night for at least two weeks, the bleaching gel is administered to the teeth. Probably the most popular method, this one has been in use for many years[9]. (fig 2)

• **Over-the-counter (OTC) bleaching** In recent years, products have become more and more popular. These products are self-applied to the teeth using gum shields, strips, or paint-on product formats. They include a modest concentration of whitening ingredient (3–6% hydrogen peroxide). Additionally, prefabricated trays, toothpastes, whitening strips, and dentifrices are available. For a maximum of two weeks, they ought to be administered twice daily. But since some of these bleaching compounds are not governed by the Food and Drug Administration, their safety may be seriously questioned[10].

2)Non vital Bleaching

Today, a variety of non-vital bleaching methods are employed, such as inside/outside bleaching, non-vital power bleaching, walking bleach, and modified walking bleach. Using the walking bleach technique, the pulp chamber of the damaged tooth is sealed off with a mixture of sodium perborate and water. This process is repeated several times until the desired bleaching effect is obtained. Known as modified walking bleach, this method is altered by sealing a pulp chamber with a mixture of 30% hydrogen peroxide and sodium perborate for a week. Internal non-vital power bleaching involves placing 30-35 percent hydrogen peroxide gel in the pulp chamber, activating it with heat or light, and keeping the tooth at a temperature of between 50 and 60 degrees Celsius for five minutes.Finally, the inside/outside bleaching technique is a combination of internal bleaching of non-vital teeth with the home bleaching technique(fig 3).[11]

BOND STRENGTH OF ENAMEL AFTER DENTAL BLEACHING

Reduction in the binding strength of composite resin restorations to enamel right after bleaching is one of the negative effects that might be seen, even though the hydrogen and carbamide peroxides produce great aesthetic results[12]. The oxygen ions that remain in the dental structure long after the bleaching gel has been removed are what cause the decrease in adhesion. The adhesive polymerization over the resin enamel junction close to the hybrid layer's base is inhibited by this leftover oxygen[13].

METHODS TO REVERSE BOND STRENGTH OF BLEACHED ENAMEL

- ♣ A waiting period
- ♣ Use of dental adhesives containing organic solvents
- ♣ Application of enzymes or antioxidant agents
- ♣ Removal of affected enamel surface are the most used methods in the literature in an attempt to restore adhesion to bleached enamel

Waiting Period: Reversing the bond strength to bleached enamel is most commonly achieved by waiting a specific amount of time after bleaching before executing adhesive treatments. Saliva's ability to buffer and remineralize reduces the negative effects of bleaching without affecting the composite resin's ability to adhere. This time frame is crucial for maintaining tooth color stability, eliminating leftover oxygen, and producing better aesthetic outcomes. It is not possible right after bleaching. Therefore, it also becomes crucial to examine alternative strategies for restoring the enamel's decreased bond strength following bleaching[14].

Application of Dental Adhesives containing organic solvents

The adhesives' organic solvents, like acetone and ethanol, might positively interact with the oxygen that is still present in the enamel to strengthen the binding. The organic solvents facilitate the removal of water from the bleached tooth surface, thereby reinstating the bond between the enamel and composite resin. According to Sung et al., the application of adhesives containing ethanol that was comparable to teeth that had not been bleached strengthened the bond[15].

Application of enzymes

Irwin Fridovich and Joe McCord identified a class of enzymes called superoxide dismutases (SODs), which catalyze the breakdown of superoxide into oxygen and hydrogen peroxide, therefore detoxifying these free radicals. SOD operates at the superoxide ion, the very beginning point of the formation of free radicals, reducing and reversing the harm that superoxide causes to cells in the body. There are two forms of SOD: manganese (Mn) SOD and copper/zinc (Cu/Zn) SOD.Cu/Zn SOD protects the cell cytoplasm, while Mn SOD protects the cell's mitochondria against damage caused by free radicals. For the first time, the nontoxic antioxidant SOD has been applied in an in vitro setting to reverse the strength of bonds. It offers fresh opportunities for cutting-edge clinical research and exploring its further application. Kavitha et al ., applied the SOD for 10 minutes on the bleached enamel which resulted in a restoration of the adhesion force that is compatible with the application of 10% sodium ascorbate for 10 minutes[16].

Application of anti-oxidant agents

- Enzymatic agents such as Catalase and peroxidase
- Nonenzymatic agents such as sodium ascorbate, flavonoids, lycopene and vitamin E have antioxidant properties and are used to reverse bond strength of bleached enamel

1) **Catalase** Compared to glutathione peroxidase; this enzymatic agent is more effective at boosting the adherence of bleached enamel. This is because of the way it works, which needs only a few molecules to have an antioxidant impact. While glutathione peroxidase generates two hydrogen ions that combine with hydrogen peroxide to make two molecules of water, catalase speeds up the process of converting hydrogen peroxide into oxygen and water. However, even after 20 minutes of application, neither enzyme is able to totally neutralize hydrogen peroxide.
2) **Sodium ascorbate** Also referred to as vitamin C, these substances are water soluble, neutral, biocompatible, and capable of eliminating active free radicals from biological systems. Because of their strong antioxidant properties, sodium ascorbate prevents early stoppage of the polymerization of free radical resin, correcting the reduced adhesion by restoring the substrate's altered redox potential. An investigation was carried out by Baidas et al. to determine how different antioxidants affected the orthodontic brackets' ability to adhere firmly to bleached enamel. They came to the conclusion that 10% sodium ascorbate can strengthen bonds and enable bracket bonding right away following bleaching[17].
3) **Antiseptics and fluorides**

   It has been suggested that antiseptic components with antioxidant capacity, such as sodium fluoride, essential oils, and chlorhexidine, can help prevent periodontal diseases and caries lesions. Nevertheless, the oxidative potential of 35% hydrogen peroxide has not been sufficiently neutralized by the application of 5% potassium nitrate or 0.05% or 2% sodium fluoride. In

order to assess the shear bond strength and debonding failure mechanisms of orthodontic brackets adhered to teeth treated with varying fluoride concentrations, Damon et al. (2018) conducted research. They came to the conclusion that the application of fluoride prophylactic pastes at different concentrations had no discernible effect on the location or shear bond strength[18].

4) **Flavonoids** The anthocyanins (malvidin and pelargonidin) found in fruits and vegetables, the catechins found in green tea, and the proanthocyanidins found in high concentrations in a variety of natural sources are the flavonoids with the strongest antioxidant qualities. A study was conducted by Mana Shamsedin et al to compare the impact of quercetin flavonoids on adhesive remnant index and postbleaching shear bond strength (SBS). It was determined that bleaching could reduce the orthodontic brackets' acceptable bond strength. The postbleaching SBS was enhanced by using quercetin or vitamin C, or by postponing the bracket bonding[19].

The catechins possess anti-oxidant, anti-mutagenic, and anticarcinogenic qualities that can lessen periodontal inflammation, tooth erosion, and cardiovascular disease. The presence of three contiguous hydroxyl groups, which react with free radicals more efficiently, justifies its strong antioxidant function. It has not been possible to reverse the bond strength by using a 10% green tea gel or a 5% green tea solution for 10 or 15 minutes after bleaching; however, applying for an hour after bleaching did restore adhesion to enamel. Green tea contains the antioxidant chemical epigallocatechin gallate (EGCG), which is a member of the catechin family.

Proanthocyanidins, high amounts of a kind of polyphenolic flavonoids can be found in foods including hazelnut leaves, lemon peel, grape seed extract, pine bark extract, and cranberries. In order to determine how applying two antioxidants—grape seed extract and sodium ascorbate—after bleaching affected the shear bond strength (SBS) of ceramic brackets, Gurbir et al conducted a study. The binding strength of ceramic brackets was found to be drastically decreased by bleaching them with 35% hydrogen peroxide. An option to delayed bonding is to treat the bleached enamel surface with 10% sodium ascorbate solution or grape seed extract (5% proanthocyanidin solution) prior to bonding. This will restore the decline in bond strength[20].

Removal of affected enamel surface

Following the bleaching procedure, aesthetic restorations such laminate and composite veneers are frequently necessary in cases of significantly discoloured dentition and the necessity for tooth form modifications. It is possible that the veneer preparation of 0.5 to 1mm will remove the affected enamel and further eliminate the weakened bond strength between the composite resin and bleached enamel, since the majority of the detrimental effects of bleaching have been detected on the enamel surface. While the quantity of remaining free radicals and structural alterations detected at various depths of dental hard tissues are unknown, it is possible that bleaching-related modifications mostly affect the enamel surface. The residual oxygen and structural changes caused by bleaching would therefore be eliminated, at least to some extent, by the enamel reduction process.

CONCLUSION:

There are a lot of studies being conducted to see if different compounds may reverse the bond strength of bleached enamel, however there aren't many in vivo and clinical trials. The use of antioxidant compounds at various doses in a short amount of time should be evaluated in more research, and it should be both therapeutically practical and effective in the short and long terms. Strategies ought to be created so as not to impede the use of adhesives and minimally invasive dentistry over bleached enamel, given their current significant influence. Antioxidants restored the bleached enamel's weakened binding strength in an efficient manner, and the longer they are applied, the more concentrated they are.

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