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AN OVERVIEW OF EFFICACY OF WHITENING TREATMENTS FOR EXTRINSIC AND INTRINSIC STAINING

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Abstract:
Aside from caries and periodontitis prevention, a rising number of oral care products focus on teeth whitening. The purpose of this paper is to outline and discuss commonly used whitening agents and their chemical efficacy. As a result, a detailed literature review on teeth whitening chemicals and products was carried out. A chemist's perspective is used to assess and debate existing whitening processes. Abrasives (mechanical removal of stains), antiredeposition agents (prevention of chromophores deposition), colorants (intended to result in a white color), proteases (protein degradation), peroxides (oxidation of organic chromophores), and surfactants (removal of hydrophobic compounds from tooth surface) are commonly used whitening agents. Although in-office whitening with peroxides is effective, it might cause tooth sensitivity or damage to the natural organic matrix of enamel and dentin. Because of the possibility for tooth wear, the use of abrasives in teeth whitening is limited, especially when toothpastes with high RDA values are employed.

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INTRODUCTION:

The color of the teeth is influenced by their inherent color as well as the presence of any extrinsic stains that may occur on the tooth surface [1]. The light absorption and scattering capabilities of the enamel and dentine have a large influence on intrinsic tooth color, with dentine having a key role in determining overall tooth color. Extrinsic color is associated with substance adsorption into the acquired pellicle on the surface of enamel, which results in staining. Extrinsic stain production is influenced by factors such as inadequate tooth brushing technique, smoking, dietary intake of colorful foods (e.g., red wine), subject age, and the use of specific cationic agents such as chlorhexidine or metal salts such as tin and iron [2,3].

Consumers and patients have long had a strong demand for white teeth, which has led to a growth in the usage of 'over-the-counter' tooth whitening solutions. To match the demands of patients and consumers, manufacturers of oral care products are continually creating novel ways for tooth whitening. As a result, there is now a vast array of items and technologies available that can be applied without the assistance of a professional [4].

Human teeth's mineral phase is composed of calcium phosphate in the form of hydroxyapatite, $Ca5(PO4)3(OH)$ [5]. Dentin is the innermost layer of a tooth and is a protein-rich bone-like biocomposite that contains around 70% hydroxyapatite and the rest is made up of proteins (mostly collagen) and water [6,7]. The enamel, or outer layer of a tooth, is a highly mineralized tissue that contains approximately 97% hydroxyapatite in the form of micrometer-long needles that form a complex hierarchical structured microstructure [5,8]. Its hardness and fracture toughness are due to a complex entanglement of hydroxyapatite needles linked by an organic protein phase. The enamel surface is protected by the pellicle, which is composed primarily of salivary proteins, carbohydrates, and lipids [9,10].

The initial hue of pure hydroxyapatite (i.e., without foreign ion substitution) is colorless/white, and this broadly applies to the integrated proteins. As a result, natural enamel is white with considerable translucency. However, when enamel ages due to constant chemical and mechanical wear (erosion, etc.), the enamel thins and becomes more translucent, allowing the dentin to become more visible and the overall tooth color to darken [11].

Furthermore, the "natural" white hue of teeth is frequently impaired by stains caused by wine, tea, coffee, smoking, and other substances. [12]. Whitening formulations for home use (for example, toothpastes in conjunction with toothbrushes) and professional use in the dental practice (for example, bleaching or professional teeth cleaning) attempt to solve this issue. In this context, whitening is defined as any method of increasing a tooth's optical whiteness [12].

Toothpaste abrasion of dental hard tissues is a significant aspect in the trade-off between cleaning efficacy and whitening toothpaste composition. As a result, whitening toothpastes contain extra chemical agents that aid in the removal and/or prevention of extrinsic stains. Many chemicals, including surfactants, peroxides, enzymes, citrate, pyrophosphates, and hexametaphosphate, have previously been investigated for stain removal efficacy [12].

Because extrinsic stains are predominantly integrated into the pellicle, enzymes such as proteases may help breakdown the stained films and facilitate their removal. Early clinical evidence showed that a highly proteolytic mixture of fungal enzymes put into toothpaste was efficient at lowering extrinsic stain levels after 6-months of use when compared to a negative control toothpaste [13]. Clinical investigations have shown that dentifrices containing papain, alumina, and sodium citrate are effective at stain removal. An in vitro study recently found that a dentifrice containing papain and bromelain (proteolytic enzymes) was more successful in eliminating stains than the control dentifrice [14].

DISCUSSION:

Tooth discolouration is caused by stains, which can be intrinsic, extrinsic, or a combination of the two [15]. Extrinsic stains typically impact the entire dentition, whereas intrinsic stains may involve all or specific teeth. Furthermore, tooth discolouration might be caused by dental operations. The most common cause for considering whitening is discolouration of the anterior teeth.

Internal tooth staining. Intrinsic tooth stains can affect the entire dentition or a single tooth and are produced by a variety of factors such as aging, systemic drugs such as tetracycline, intra-pulpal hemorrhage, calcific metamorphosis, pulp necrosis, and certain disorders or tooth abnormalities. As humans age, enamel thins due to use, while dentin thickens due to dentin apposition; such physiological changes in tooth structure alter optical qualities, resulting in increasing darkening of tooth color [16]. Furthermore, enamel cracking, crazing, and wear tend to increase with tooth use length, increasing the likelihood of cumulative extrinsic stains from food and beverages. Tetracycline was widely used in the 1950s and 1960s for infection prevention and treatment, and was occasionally administered on a daily basis for a lengthy period of time. It is now widely understood that ingesting tetracycline during tooth formation can result in severe, unique tooth discolouration. Although tetracycline is no longer used for lengthy periods during tooth formation, dentists are nevertheless faced with the difficulty of dealing with tooth discoloration in persons who used it as children before it was discovered that it might cause severe tooth stains [17]. Extrinsic teeth stains are most typically induced by the colored components of numerous foods and beverages, such as coffee, tea, and red wine, as well as smoking. The role of acquired pellicle in tooth-surface discoloration is widely known. Extrinsic stains are seen on the tooth surface and can be exacerbated by porous and rough enamel. The structural abnormalities in the enamel can change the optical qualities of the tooth, making it appear discolored, and the porous and rough surface of the deficient enamel attracts extrinsic stains found in the oral cavity [17].

It is critical to realize that the etiology of extrinsic staining varies greatly between individuals and is frequently impacted by oral hygiene habits, nutrition, and lifestyle. A wide range of chromogenic oral microorganisms are capable of producing pigment molecules and, as a result, are responsible for some tooth stains; for example, a 2010 article reported a case of blue tooth staining caused by Pseudomonas aeruginosa, a bacterium commonly associated with chronic pulmonary infections [18].

A number of studies have been published that describe the use of clinical indices for stain evaluation. These indexes are quick and simple to use, however their subjectivity causes dependability concerns. Image analysis has already been utilized as an objective way to assess stain build up in vitroon acrylic and enamel slabs to overcome such issues [19]. It was also demonstrated to be a useful tool for clinically assessing plaque and stains.

The stain removal performance of a new dentifrice was evaluated solely in terms of Lightness values. The mean pre-treatment Lightness value did not differ significantly between the test and control groups. However, the mean post-treatment Lightness score for test dentifrice was significantly greater than the control dentifrice. A prior in-vitro study[10] employing this test dentifrice yielded similar results. Clinical investigations employing toothpaste containing a mixture of papain, alumina, and sodium citrate (Rembrandt) have also shown that it removes stains effectively [20,21].

To create a whitening effect, various approaches and techniques have been employed to eliminate tooth-surface stains. Certain tooth discolorations, such as those caused by certain systemic illnesses or dental treatments, necessitate the care of a dental professional. Tooth whitening can be accomplished in general by removing external and intrinsic stains with peroxide-based bleaching treatments and abrasive materials such as dentistry prophylaxis pastes and dentifrices [21].

Peroxide-based tooth bleaching. Although the mechanics of tooth bleaching remain unknown, there is little disagreement about the whitening efficiency of peroxide-based teeth- bleaching products [22]. It is widely assumed that the bleaching effects are caused by free radicals produced by H2O2. As H2O2 diffuses through the enamel and dentin, it generates free radicals that react with pigment molecules to break their double bonds, causing human eyes to perceive a lighter tooth color. This notion also helps to explain the regularly observed shade rebounding quickly after a bleaching treatment, which is most likely due to double bond reformation.

However, there have been safety concerns raised about the use of peroxides for tooth whitening, owing mostly to the potential toxicologic effects of oxidative free radicals. With the collection of study data, the safety concerns about teeth bleaching have largely subsided. However, negative consequences have been documented, and the danger appears to be related to the quality of the bleaching substance, the technique utilized, and people's reactions to the bleaching treatment. The most well-known concerns associated with tooth bleaching are mostly local, including as tooth sensitivity and gingival irritation, as well as potential harmful effects on enamel and restorative materials. At the moment, a number of countries control peroxide-based tooth-bleaching solutions, limiting their peroxide content and restricting their distribution to dental professionals. There have also been ongoing arguments and legal issues in the United States in recent years about whether peroxide-based bleaching can be conducted by practitioners without dental credentials [23,24].

Prophylaxis of the teeth. Dental prophylaxis is a common technique that aims to remove dental plaque and calculus in order to avoid dental cavities and gingival irritation. The abrasives in the preventive paste remove stains from the tooth surface, resulting in a whitening effect. As a result, the suggested frequent dental prophylaxis serves two functions. Dental prophylaxis necessitates an office visit, with the primary goal of removing dental plaque and calculus to maintain dental and gingival health [25].

Dentifrice for teeth whitening. Brushing teeth with dentifrice has long been acknowledged as an important step in maintaining personal oral hygiene. The original objective of brushing teeth with a dentifrice was to eliminate food debris and dental plaque, in addition to producing a clean and refreshing feeling in the oral cavity. It is worth noting that a recent systematic analysis concluded that the use of dentifrice in conjunction with toothbrushing does not improve the effectiveness of mechanical plaque removal [26]. Dentifrice, on the other hand, can be a carrier of active substances for further advantages. Dentifrice has been widely regarded as a key vehicle for delivering fluoride for caries prevention and additional agents for other effects such as anticalculus, reduction of oral malodor, desensitization, anti-inflammation, and tooth whitening [27].

Poor oral hygiene and insufficient toothbrushing not only raise the risk of developing numerous dental and oral disorders, but also make staining easier. Extrinsic tooth discoloration can be exacerbated by certain food habits and smoking. Because of the customer demand in whiter teeth, whitening dentifrice has grown in popularity due to a number of benefits. Its use needs little extra work, and it is widely available, simple to use, and reasonably inexpensive. The whitening dentifrice is especially appealing to specific groups, such as smokers who develop extrinsic stains but are advised against tooth bleaching due to concerns about peroxide's potential detrimental effects [28]. There is a wide range of whitening dentifrices on the market. Most whitening dentifrices produced with specially tailored abrasive systems contain more abrasives and detergents than normal dentifrices. Some of the treatments may additionally contain other chemicals, such as low concentrations of H_2O_2, to improve abrasive cleaning by assisting with the removal of extrinsic stains.

However, this conclusion has not been consistent; Lobene [29] discovered only minimal associations between abrasiveness and cleaning performance among the commercial dentifrices studied with varied abrasive systems. In a laboratory study, researchers used conventional in vitro procedures to evaluate the abrasivity, enamel-polishing properties, and stain-removal effectiveness of 26 commercial dentifrices of various compositions for cleaning, whitening, and polishing capabilities; they also investigated the relationship between stain removal and abrasivity [30]. The relative dentin abrasivity (RDA) method was used to quantify abrasivity, and the pellicle cleaning ratio (PCR) was used to determine stain removal performance. Using the RDA and PCR values, the cleaning efficiency index value was determined. The researchers discovered that while all dentifrices eliminated extrinsic discoloration and caused some dentin abrasion, the RCA and PCR scores varied greatly amongst products, ranging from 36 to 269 and 25 to 138, respectively. Furthermore, dentifrices with high PCR scores had higher RDA values more often than not, whilst some with lower RDA values, i.e. reduced abrasivity, produced a higher PCR score and hence a better cleaning efficiency index value, i.e. higher stain-removal efficiency. However, when the researchers examined the whole data, they discovered no consistent association for these abrasive system parameters. In general, whitening dentifrices were more abrasive, although there were exceptions, and a direct relationship between a dentifrice's stain-removal effectiveness and abrasivity was not always visible. More recent research has proven that a dentifrice with a low abrasiveness can provide significant cleaning efficacy and, as a result, a tooth-whitening effect [31].

Manufacturers of oral care products are fully aware of consumer discontent with perceived tooth color and, in response, have developed a wide range of contemporary toothpastes to solve the issue. Most of them contain the same fundamental functional components, each of which serves a distinct purpose in the formulation. These include: solid cleansing abrasive materials, humectants for solubilization of other ingredients and to keep the formulation from drying out; thickening agents to define the rheological properties of the formulation; surfactants to generate foam and impart desirable sensorial properties during use; active agents such as fluoride to provide health benefits, flavor, sweetener, opacifying agents; colors for distinctive taste and appearance; and buffering agents.

Abrasives are insoluble ingredients that are added to toothpaste to aid in the physical removal of stains, plaque, and food debris. Abrasives used in toothpaste have been used for over 2000 years, with concoctions employing bones and pulverized shells being documented. Abrasives used in modern toothpastes include hydrated silica, calcium carbonate, dicalcium phosphate dihydrate, calcium pyrophosphate, alumina, perlite, and sodium bicarbonate [33]. When cleaned regions are brushed to remove immature stains, abrasives have been demonstrated to effectively remove extrinsic stains while also preventing dental stains from regenerating. Abrasive particles can become caught between the tooth-brush bristle and the discolored tooth surface while brushing. The stain can be removed because the abrasive is physically tougher than the stain, leaving a clean tooth surface. This method clearly shows that abrasive cleaning primarily affects external stains and has no effect on underlying intrinsic discolouration or the natural hue of the tooth. The toothbrush's access to stained portions of the teeth, particularly in interproximal areas, gingival areas, and malocclusion sites, may further limit abrasive cleaning [33].

Particle hardness, shape, size, size distribution, concentration, and applied load are some of the important characteristics that have been shown to affect the abrasive cleaning process [32]. For example, it has been demonstrated that the abrasive wear rate increases linearly as particle size grows up to a certain size before becoming size independent [34]. If the abrasive particles are too large, they will lose their abrasive properties because they will not be retained by the toothbrush bristle and will be swept away. Similarly, as particle concentration rises, so will abrasion, until the probability of particles being collected by the brush approaches unity. Any additional particle addition will be unsuccessful in increasing the rate of abrasion, and stain removal efficiency will approach a plateau [35]. Whitening toothpastes may contain extra chemical compounds that help with the removal and/or prevention of extrinsic stains. Surfactants, peroxide, enzymes, citrate, pyrophosphates, and hexametaphosphate have all been examined earlier [36].

Peroxide's intrinsic teeth whitening efficiency is well proven in particular delivery forms like as trays, strips, and paint-on, however the application of peroxide in toothpaste is significantly more difficult due to formulation issues and the relatively limited exposure intervals. Despite these difficulties, toothpastes containing oxidative chemistries such as peroxide, peroxide sources, and sodium chlorite have been described. A 1% hydrogen peroxide/sodium bicarbonate toothpaste, for example, was demonstrated in vitro to considerably reduce tooth yellowness (b*) and enhance lightness (L*) of tooth samples when compared to a silica and sodium bicarbonate control toothpaste. Furthermore, following 6 weeks of product use, a toothpaste containing 0.5% calcium peroxide was proven to dramatically reduce natural extrinsic discoloration vs a placebo toothpaste [36]. Another example is toothpaste packaged in a dual-chambered container with one stream containing 1% hydrogen peroxide and the other stream having high cleaning silica, phosphate salts, and manganese gluconate, which can activate the peroxide during usage. This toothpaste has been shown to whiten teeth in a series of in vitro studies; significantly remove more extrinsic stain versus a silica control toothpaste after 2 and 4 weeks; significantly remove more extrinsic stain and give a greater reduction in mean tooth shade than a silica/hexametapho- sphate containing whitening toothpaste after 6 weeks, and significantly prevent extrinsic stain formation versus a silica/ hexametaphosphate whitening toothpaste [37].

CONCLUSION:

There are two basic ways to whitening: chemical bleaching with peroxides and mechanical cleaning with toothpaste abrasives. Chemical bleaching produces good results, especially when administered in a controlled atmosphere, such as a dental practice, with high peroxide concentrations. Mechanical cleaning makes use of abrasives that are harder than stains but softer than enamel. Baking soda is an excellent abrasive for removing stains and whitening teeth. Its mild abrasiveness, along with clinically established stain removal and whitening performance, provides a unique balance in achieving maximum benefits with lowest dangers. The majority of research efforts have so far concentrated on the stain-removal and tooth-whitening efficacy and clinical safety of baking soda dentifrices when used with manual tooth brushes, with only a few studies studying their effects when used with power brushes, for which more research is suggested. In the literature, a number of tooth whitening in vitro models testing the effects of toothpaste have been published. These typically assess a toothpaste formulation's ability to remove a model extrinsic stain from a substrate such as enamel or hydroxyapatite, though other methods have been described that assess stain prevention approaches or changes in the intrinsic color of tooth specimens after extensive brushing times. To examine the efficacy of whitening toothpaste, numerous clinical procedures and models are used. Changes in natural stain or chlorhexidine/tea generated stain are commonly measured over 2-6 weeks to determine stain removal or prevention. Overall tooth color change was assessed in certain clinical investigations using techniques such as Vita shade guides, colorimeters, and image analysis of digital photos of teeth. The majority of clinical investigations compare the efficacy of a teeth whitening formulation to the efficacy of a non-whitening control formulation.

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