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Major clinical approaches to tooth whitening techniques and differences in terms of sensitivity and protection: a systematic review

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Abstract

Introduction: Tooth whitening is an initial step in the analysis and reproduction of the aesthetics of the smile, so the dentist must know how to diagnose the causes of color changes, and recommend whitening before proposing the appropriate dental procedure. With technological advances, tooth whitening techniques have emerged to facilitate their use improve comfort and safety, and reduce time spent performing the technique. The conventional means of external tooth whitening is with carbamide peroxides or light-activated hydrogen or not. However, both at-home and in-office whitening procedures cause tooth sensitivity. There is a new whitening proposal on the market without the use of whitening gels, thus reducing post-treatment sensitivity. This proposal highlights ultraviolet light as a whitening agent. **Objective:** It was to carry out a concise systematic review of the main clinical approaches to tooth whitening techniques, to point out the differences between them in terms of sensitivity and tooth protection. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from January to February 2024 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 178 articles were found, 40 articles were evaluated in full and 20 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 21 studies with a high risk of bias and 31 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=67.4%>50%. It was concluded that tooth whitening can be indicated in practically all situations in which tooth darkening occurs, such as pulp tissue decomposition, internal hemorrhage, trauma, use of medications, restorative materials, and systemic conditions such as fluorosis, jaundice, and fetal erythroblastosis, among others. others. Contraindications for tooth whitening treatment occur in children under 10 years of age. Whitening using the home technique uses products with lower concentrations, between 10% and 22% carbamide peroxide. In-office, 16% carbamide peroxide was effective. In office-based tooth whitening, higher concentrations of whitening substances are used and laser, LED, ultraviolet, and halogen light can be used to intensify the whitening process. Patients undergoing vital teeth whitening report sensitivity or discomfort during treatment. Oxidative stress generated by bleaching agents can cause apoptosis and damage to periodontium DNA (genotoxicity) and cellular cytotoxicity. A new generation of whitening agents with low concentrations of hydrogen peroxide (3.5% and 15%) was introduced on the market for in-office teeth whitening, aiming to achieve greater safety and efficiency in tooth whitening.

Keywords: Dental care. Tooth whitening. Tooth whitening techniques. Aesthetic. Sensitivity. Protection.

Introduction

Aligned, white, and well-contoured teeth are relevant for the majority of the population. This search for the "perfect smile" can be influenced by the media, professionals, and patients themselves, reflecting as a synonym for health in the oral cavity, in addition to influencing their psychosocial state [1]. The process of tooth darkening occurs due to the formation of chemically stable structures, responsible for the progressive installation of stains on the dental crown. Knowledge of the etiology of tooth stains by the dental surgeon is relevant for choosing an appropriate treatment [1,2].

Changes in the color of the tooth structure can be due to extrinsic and intrinsic factors. Extrinsic stains normally originate from the environment and are associated with coloring pigments such as tobacco and coffee, the use of certain types of medications, and the accumulation of bacterial plaque, being surface stains that come off more easily after prophylaxis. Intrinsic stains can be congenital, related to dentinogenesis and amelogenesis imperfecta or they can be acquired, from pulp necrosis, fluorosis, formation of reparative dentin [3,4].

Since 1861, it has been reported that the first whitening was described by M´quillen in the renowned periodical The Dental Cosmos, in an article that highlighted the importance of this topic at the New Haven Convention. Where he advocated the importance of knowing the chemical characteristics of the substances in question, citing sulfur dioxide and Labarraque liqueur (2.5% sodium hypochlorite) as bleaching agents [3]. Nowadays, the essence of the whitening technique remains 30% hydrogen peroxide and heat in vitalized teeth and for pulped teeth, sodium perborate is associated with 30% hydrogen peroxide [5].

In this context, there are several whitening techniques cited in the literature, with different types of substances such as carbamide peroxide and hydrogen peroxide and in different concentrations. In addition to the variety of whitening substances, light sources such as halogen, laser, LED and ultraviolet can also be used to enhance the action of the whitening substance [5].

Also, whitening is a technique that increases dentin permeability, increasing tooth sensitivity especially when there is an increase in temperature. The lower the heat generation of the whitening system, the lower the sensitivity. In this sense, new whitening techniques must evolve, in addition to reducing the irradiance of light that must photochemically activate the whitening gel [5,6].

The most common adverse effect associated with vital teeth whitening is tooth sensitivity. The incidence of post-bleaching hypersensitivity is 10 to 90%, of mild or moderate intensity, however, it can become intense and result in treatment interruption. Sensitivity is caused by the passage of oxygen ions through the enamel and dentin, reaching the pulp tissues, which will result in sensitivity, and the treatment is contraindicated for patients with dentin sensitivity [1,2].

In an attempt to counteract dentine sensitivity, some manufacturers add potassium nitrate and fluoride to whitening products, although this appears to result in only a limited reduction in the sensitivity experienced by patients. Low-intensity laser therapies for desensitization have also been reported in the literature [1,3,7]. Tooth sensitivity continues to be a major concern, although many studies and techniques combine desensitizing approaches and whitening substances, it is important to explore alternative desensitization regimens that are capable of reducing or eliminating sensitivity and discomfort [1].

Therefore, the present study aimed to carry out a concise systematic review of the main clinical approaches to tooth whitening techniques, to point out the differences between them in terms of sensitivity and tooth protection.

Methods

Study Design

The present study followed the international systematic review model, following the rules of PRISMA (preferred reporting items for systematic reviews and meta-analysis). Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 02/20/2024. The methodological quality standards of AMSTAR-2 (Assessing the methodological quality of systematic reviews) were also followed. Available at: https://amstar.ca/. Accessed on: 02/20/2024.

Data Sources and Research Strategy

The literary search process was carried out from January to February 2024 and was developed based on Scopus, PubMed, Web of Science, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various to the present. The descriptors (MeSH Terms) were used: *"Dental care. Tooth whitening. Tooth whitening techniques. Aesthetic. Sensitivity. Protection"* and using the Boolean "and" between the MeSH terms and "or" between historical discoveries.

Study Quality and Risk of Bias

Quality was classified as high, moderate, low, or very low in terms of risk of bias, clarity of comparisons,

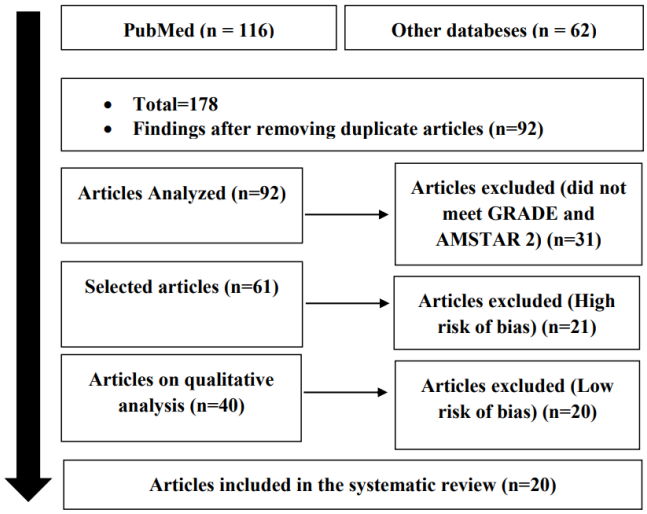
precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using the Cohen test (d).

Results and Discussion

Summary of Findings

A total of 178 articles were found that were subjected to eligibility analysis, with 20 final studies being selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. The biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies showed homogeneity in their results, with X^2=67.4%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 21 studies with a high risk of bias and 31 studies that did not meet GRADE and AMSTAR-2.

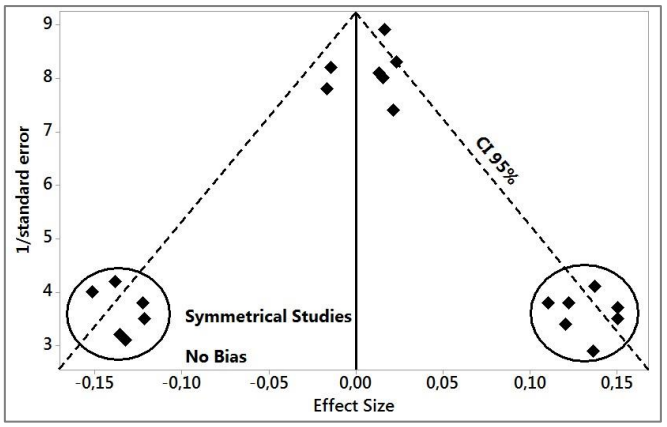
Figure 1. The article selection process by the level of methodological and publication quality.



Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using the Cohen Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both between studies with a small sample size (lower precision) that are shown at the bottom of the graph and in studies with a large sample size that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=20 studies).



Source: Own authorship.

Major Clinical Outcomes

Based on clinical findings, a randomized controlled clinical trial determined the whitening efficacy and intensity and absolute risk of tooth sensitivity of double whitening when prefilled at-home whitening trays were used between in-office whitening intervals. An in-office whitening agent containing 35% hydrogen peroxide was used. A tray prefilled with a bleaching agent containing 6% hydrogen peroxide was used for at-home bleaching. Sixty-six individuals were randomly distributed into three groups. Group I: home whitening was performed 10 times between in-office whitening treatments. Group II: home whitening was performed five times between in-office whitening treatments. Group III: only in-office whitening was performed. Although double bleaching with a pre-filled tray and in-office bleaching have greater whitening capacity than in-office bleaching alone, the intensity and absolute risk of tooth sensitivity were similar [8].

Furthermore, a study clinically evaluated the effectiveness of two different home whitening protocols and determined which is more effective: applying the whitening gel (carbamide peroxide 16%) every 24 hours (Group A) or every 48 hours (Group B) for 2 weeks. Group C received a placebo gel (glycerin) without peroxide, which was applied every 24 hours for 2 weeks. Differences in terms of tooth sensitivity were also analyzed. A sample of 60 patients was divided into three groups of 20 patients. No statistically significant differences were found between Groups A and B. Therefore, 16% carbamide peroxide was equally

effective when applied with either protocol and achieved the same results, but the 48-hour application protocol produced less sensitivity than the 24-hour application protocol [9].

The mechanisms for color perception cannot exist without light, that is, the shape and color of the dental element can only be perceived if the tooth emits a light frequency sensitive to human eyes through a beam of light. The variation of electromagnetic waves between 380-760 nm can be perfectly discernible with the naked eye. The short wavelengths of 400 nm correspond to bluish colors, the medium wavelengths of 540 nm correspond to greenish colors and the long wavelengths correspond to reddish ones. Thus, color is nothing more than an energy wave of a specific length; it is the visual perception of a given wavelength that determines the colors that the eyes detect [1,3].

In this context, it is known that color has 3 dimensions: hue, chroma, and value. Hue is used to define color, for example, red, yellow, and blue. The value is related to the variation in brightness and reflection of light, and the chroma or saturation determines the intensity of the hue or its degree of saturation. During whitening, teeth may change saturation or chroma, but not in hue, for example, a person with color C3 may, after treatment, present color C1, but not change the hue to B1 or A2 [10,11].

Dental darkening occurs due to pigments impregnated in the dental structure for a variety of reasons, such as food coloring, trauma, intracanal medication, and internal dental bleeding, among other causes. When these pigments form molecules capable of reflecting light at a wavelength visible to the human eye and whose intensity is greater than the light reflected by the tooth structure, the color of the pigment then predominates and a darkened tooth is observed [11,12].

In this aspect, extrinsic pigmentation is acquired from the environment after tooth eruption, it is the result of the precipitation of food colorings on the bacterial plaque and acquired film covering the tooth enamel and by chromogenic bacteria. The foods with the greatest coloring potential are coffee, soft drinks, black tea, food coloring, red wine, and tobacco. This type of pigmentation is generally removed after prophylaxis, however, extrinsic pigments that remain in contact with the enamel and dentin for a long time can become intrinsic due to their penetration through enamel defects (cracks) and exposed permeable dentin. Intrinsic pigmentation can involve the enamel and/or dentin, being of congenital origin (dentinogenesis or amelogenesis imperfecta) or acquired (fluorosis, tetracycline stains, pulp necrosis, metal impregnation, aging) [13].

Pigmenting molecules are formed by long and complex macromolecular carbon chains, which are housed inside the tooth structure. These long chains inside the teeth cause more light to be absorbed than reflected, making the tooth structure darker [14].

Dental whitening can be indicated in practically all situations in which darkening of the teeth occurs, such as decomposition of the pulp tissue, internal bleeding, trauma, use of medications, restorative materials, and systemic conditions such as fluorosis, jaundice, and fetal erythroblastosis, among others. Among its main contraindications, we have application to pregnant women, breastfeeding women, children under 10 years of age, patients who have teeth with exposed dentinal tubules, and individuals who are unable to give up the smoking habit during the treatment period [14].

Therefore, contraindications to tooth whitening treatment occur for children under 10 years of age, as in these children there is a greater possibility of teeth darkening after trauma and then returning to their normal color without treatment than in young people and adults. In them, the dentinal canaliculi are wider, which ends up allowing the reabsorption of hemoglobin that penetrated the tubules as a result of trauma, thus making bleaching treatment unnecessary. The basic whitening process involves oxidation, which consists of a chemical process where organic materials are converted into carbon dioxide and water. Pigments are complex compounds, with large amounts of carbon molecules, which are broken down and converted into intermediate compounds (smaller carbon chains), resulting in lighter teeth [14,15].

Furthermore, regardless of the technique or product used, the mechanism of action of whitening agents is based on the release of reactive forms of oxygen, due to the interaction of hydrogen peroxide with the tooth structure. Hydrogen peroxide is an oxidizing agent capable of producing free radicals, by releasing oxygen (O_2), it reduces the complex carbon chain of the pigment (which absorbs the blue spectrum of light), into smaller molecules with free hydroxyls (which do not absorb blue light) and in this way, they begin to reflect blue light along with the green and red spectrums; mixing colors gives the H_2 whitening effect [16].

This chemical reaction changes the type, number, and relative position of the atoms that make up these molecules. During bleaching, carbon chains are transformed into CO_2 and H_2O, being gradually released along with the nascent oxygen. The saturation point is the moment at which maximum lightening occurs, from this stage onwards the pigments are no longer lightened. This fact is of high clinical relevance, as the indiscriminate use of high concentrations and prolonged

times can cause undesirable damage to the dental structure. This can range from simple transient pulp hyperemia, as is commonly observed in most cases of bleaching, to pulp necrosis or degradation of the crystalline structure of the enamel, which occurs when the bleaching agent begins to act on other carbon compounds, such as proteins. of the enamel matrix [17].

Furthermore, the factors that interfere with the decomposition of hydrogen peroxide in the oral cavity, forming ions and free radicals, are temperature, pH, light, coenzymes, and the interaction with metals such as Fe, Cu, and Ti. External whitening techniques They aim to make pulped teeth lighter and can be carried out both at home, by the patient, or in the office, with products based on carbamide peroxide, hydrogen peroxide, and sodium perborate in different concentrations. Whitening using the home technique uses products with lower concentrations, between 10% and 22% carbamide peroxide. In office-based tooth whitening, higher concentrations of whitening substances are used and laser, LED, ultraviolet, and halogen light can be used to intensify the whitening process [17,18].

From a physical/chemical point of view, the efficiency of a bleaching agent is directly proportional to the rate of resulting chemical reactions, that is, its efficiency is limited by the concentration of the bleaching agent, the time of contact with the tooth structure, its reactivity and by the amount of complex molecules present. The use of methods that increase the rate of chemical reactions allows the development of faster, more efficient, and clinically convenient techniques [19].

In this way, several methods have been developed to enhance chemical reactions, such as chemical catalysis by Fenton reactions, thermocatalyzation with heat units, lasers, and high-intensity lamps (plasma arc, xenon, and halogen), photothermal conversion (low-intensity lights - LED and LED/Laser) and ultraviolet light [1,7].

Due to the constitution and form of reaction of hydrogen peroxide, it can be chemically classified according to the type of oxidative process, which can be homogeneous advanced oxidation (POAHo) or heterogeneous advanced oxidative process (POAHe). Due to its characteristic of high instability and reactivity, POAHo can have its reactions catalyzed by the increase in temperature, the difference between the ambient temperature and the oral cavity, in this way, the whitening will be catalyzed by the mixture of the components of the whitening gel and will not depend on no light source. This is the principle of action of homemade whitening gels and some in-office whitening products that do not depend on irradiation for the whitening process to occur. However, the whitening gel can receive an energy source to accelerate its process [7,19].

In this sense, the POAHe group has its bleaching action dependent on a previous chemical reaction, called the Fenton (Fe^{2+}/H_2O_2) or Photo/Fenton ($Fe^{2+}/H_2O_2/UV$) process, where the bleaching action depends on both the mixture and the action of a UV light. In cases where the whitening gel does not require activation by light, the final aesthetic result using light will be the same as that obtained without using it, however, the time needed to achieve it will be shorter in the groups subjected to irradiation. The use of combined LED/Laser light is a Brazilian technology based on the conversion of light energy into thermal energy in the whitening gel applied to the tooth surface. This increases molecular vibrations, promoting a higher rate of formation of free radicals, and accelerating the whitening process without the risk of heating the tooth structure. However, the use of these methods is controversial [20].

There are reports that some whitening agents are more effective when photocatalyzed, while others do not have their effectiveness altered by the application of this electromagnetic energy and that the use of light sources is inefficient, unnecessary, and potentially harmful to the tooth structure, resulting in greater sensitivity and discomfort. to patients. The whitening process persists for a few days after the end of the applications and authors have demonstrated that the final aesthetic result is similar regardless of whether photocatalysis is used or not [19,20].

The decomposition of hydrogen peroxide and the release of free radicals, responsible for whitening, can be accelerated by supplying electromagnetic energy through an external light source. The big difference in photoactivated whitening techniques is laser light and LED (light emitting diodes) that emit light in a narrow band, with electromagnetic energy of highly selective spectral purity, which increases the absorption of light by the dye, accelerating the decomposition of peroxide and the whitening process. The advantage of photochemical activation is that the light acts on the product and heats the tooth structure very little [1].

Still in this scenario, patients undergoing vital teeth whitening report sensitivity or discomfort during treatment, reaching rates of up to 87%. Dental sensitivity during whitening is caused by the harmful effect of hydrogen peroxide on pulp tissues, as well as by the stimulation of neural receptors. The cytotoxic effects of chemical agents used for tooth whitening associated with their ability to trigger a significant inflammatory response in the pulp would harm the maintenance of the dentin structure. Pulp inflammation can also be explained by the fact that hydrogen

peroxide, even in low concentrations, can easily penetrate the enamel and diffuse deep into the dentin reaching the pulp, especially in regions where the dentin meets - if exposed, in areas of gingival recession, abrasions, erosions, wear, defects in the enamel, defects in the dental-enamel junction, or marginal areas between the tooth and the restoration. Oxidative stress, generated by bleaching agents, causes apoptosis and damage to periodontium DNA (genotoxicity) and cellular cytotoxicity [1,5,7].

In this aspect, the literature is also controversial, it is stated that in-office whitening causes more sensitivity due to the high concentration of hydrogen peroxide used, especially if this is catalyzed by light sources or laser, normally associated with excessive heating of the tooth structure. due to the use of high-intensity irradiation. On the other hand, they state that home whitening causes tooth sensitivity, in all clinical articles selected for a systematic review on this topic, which demonstrates that, even in small concentrations, peroxide can cause pain and discomfort to patients [5].

A new generation of whitening agents with low concentrations of hydrogen peroxide (3.5% and 15%) was introduced on the market for in-office teeth whitening, aiming to achieve greater safety and efficiency in tooth whitening. These are substances that have reactions dependent on heterogeneous advanced oxidative processes (POAHe) in which the action of hydrogen peroxide is catalyzed and enhanced by a semiconductor agent, normally titanium dioxide. The new generation of whitening products containing TiO2 nanoparticles is safer and more effective than traditional formulations as they promote whitening without the presence of hydroxyl, which minimizes damage to the tooth structure [1,15].

Finally, LEDs have numerous advantages, one of which is the reduction in dentin sensitivity when associated with therapeutic lasers. It is an affordable piece of equipment, uses less electricity, and does not cause an increase in the temperature of the tooth structure. Nowadays, there are several ways to perform tooth whitening. Recently, ultraviolet light has been used for tooth whitening, and it is proposed to exclude the use of chemical whitening agents such as hydrogen peroxide or carbamide. Whitening using ultraviolet light is recommended by the manufacturer for patients with dentin hypersensitivity, gingival retractions, enamel microfractures, dentin exposures, and restorations with extensive restorative material/enamel interface [11,15].

Conclusion

It was concluded that tooth whitening can be indicated in practically all situations in which tooth darkening occurs, such as pulp tissue decomposition, internal hemorrhage, trauma, use of medications, restorative materials, and systemic conditions such as fluorosis, jaundice, and fetal erythroblastosis, among others. others. Contraindications for tooth whitening treatment occur in children under 10 years of age. Whitening using the home technique uses products with lower concentrations, between 10% and 22% carbamide peroxide. In-office, 16% carbamide peroxide was effective. In office-based tooth whitening, higher concentrations of whitening substances are used and laser, LED, ultraviolet, and halogen light can be used to intensify the whitening process. Patients undergoing vital teeth whitening report sensitivity or discomfort during treatment. Oxidative stress generated by bleaching agents can cause apoptosis and damage to periodontium DNA (genotoxicity) and cellular cytotoxicity. A new generation of whitening agents with low concentrations of hydrogen peroxide (3.5% and 15%) was introduced on the market for in-office teeth whitening, aiming to achieve greater safety and efficiency in tooth whitening.

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Ethical Approval

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Informed consent

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Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

It was applied by Ithenticate@.

Peer Review Process

It was performed.

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