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REVIEW

Tooth whitening: esthetic benefits and clinical challenges

Blanqueamiento dental: beneficios estéticos y desafíos clínicos

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ABSTRACT

Introduction: tooth whitening has been widely used as an esthetic procedure, growing in demand since its initial description in 1864. This process uses chemical agents such as hydrogen peroxide, capable of oxidizing chromogens present in tooth enamel, lightening the teeth. However, its continued use can have side effects, including demineralization of the enamel and alterations in the oral microbiota, such as the growth of Candida albicans.
Development: several studies have analyzed the effects of hydrogen peroxide at different concentrations. At high concentrations, such as 35 %, its capacity to alter the morphology and mineral content of dental enamel, increasing its roughness and favoring the adhesion of microorganisms has been demonstrated. The formation of biofilms by bacteria and fungi, such as Streptococcus mutans and Candida albicans, has been the subject of debate, with contradictory results regarding their prevalence on surfaces treated with bleaching agents. This study found that the control group, without peroxide treatment, presented greater adhesion of C. albicans, which could be attributed to an antimicrobial effect of the oxidizing agent.
Conclusion: tooth whitening, although effective as an esthetic procedure, presents clinical challenges due to its potential adverse effects. The findings highlight the need for further research to fully understand the impact of these agents on the oral microbiota and enamel. Future studies should include larger samples and employ advanced techniques to improve the validity of the results and optimize the safety of the procedures.

Keywords: Tooth Whitening; Hydrogen Peroxide; Tooth Enamel; Candida Albicans; Oral Microbiota.

RESUMEN

Introducción: el blanqueamiento dental ha sido ampliamente utilizado como procedimiento estético, creciendo en demanda desde su descripción inicial en 1864. Este proceso utiliza agentes químicos como el peróxido de hidrógeno, capaz de oxidar cromógenos presentes en el esmalte dental, aclarando las piezas dentarias. Sin embargo, su uso continuo puede tener efectos secundarios, incluyendo desmineralización del esmalte y alteraciones en el microbiota oral, como el crecimiento de Candida albicans.
Desarrollo: diversos estudios han analizado los efectos del peróxido de hidrógeno en diferentes concentraciones. En concentraciones altas, como el 35 %, se ha demostrado su capacidad para alterar la morfología y el contenido mineral del esmalte dental, aumentando su rugosidad y favoreciendo la adhesión de microorganismos. La formación de biopelículas por bacterias y hongos, como Streptococcus mutans y Candida albicans, ha sido objeto de debate, con resultados contradictorios respecto a su prevalencia en superficies tratadas con agentes blanqueadores. Este estudio encontró que el grupo control, sin tratamiento de peróxido, presentó mayor adhesión de C. albicans, lo que podría atribuirse a un efecto antimicrobiano del agente oxidante.

Conclusión: el blanqueamiento dental, aunque efectivo como procedimiento estético, presenta desafíos clínicos debido a sus posibles efectos adversos. Los hallazgos resaltan la necesidad de investigaciones adicionales para entender completamente el impacto de estos agentes sobre el microbiota oral y el esmalte. Estudios futuros deben incluir muestras más grandes y emplear técnicas avanzadas para mejorar la validez de los resultados y optimizar la seguridad de los procedimientos.

Palabras clave: Blanqueamiento Dental; Peróxido De Hidrógeno; Esmalte Dental; Candida Albicans; Microbiota Oral.

INTRODUCTION

Teeth whitening is currently one of the cosmetic procedures patients most frequently request. The American Academy of Cosmetic Dentistry has reported that teeth whitening procedures increased by just over 300 % between 2002 and 2007 and continue to grow by around 25 % annually.[1,2,3] Teeth whitening was first described in 1864 by Truman, who used various compounds such as sodium hypochlorite, sodium perborate, and hydrogen peroxide on non-vital teeth.[2]

Whitening is defined as a clinical procedure by which one or more teeth can be lightened using chemical agents such as peroxides or chlorides in various concentrations; this method removes coloring substances, also called chromogens.[4,5] Among the types of whitening, professional whitening is applied in the dentist's office, and home whitening is done with professional supervision.[6,7,8,9] Among the substances used, hydrogen peroxide in its various concentrations is one of the most commonly used.[10] Hydrogen peroxide (H2O2) is a highly reactive oxidizing agent that is clear, colorless, odorless, highly soluble in water, unstable, and caustic.[9] Its low molecular weight facilitates its high diffusion power through tissues. When it comes into contact with saliva, hydrogen peroxide dissociates into oxygen and hydroxyl radicals (HO), with oxygen being responsible for the whitening effect, acting as an oxidizing agent and forming free radicals, hydrogen peroxide anions, and reactive oxygen molecules, which are responsible for breaking the double bonds in the chains present in the chromophores to make them small particles, through an oxidation-reduction process.[2]

It has also been studied that continuous use of peroxides can alter the flora and promote the growth of Candida albicans and papilla hypertrophy.[9] Candida albicans is an ordinary member of the oral microflora, isolated in 30 to 50 % of the population. Its taxonomy is as follows.

- Kingdom: Fungi
- Division: Deuteromycota
- Class: Blastomycetes
- Family: Cryptococcaceae
- Genus: Candida
- Species: albicans

C. albicans usually appears as an oval yeast-like cell measuring 2 to 4 microns, with thin walls; however, filamentous forms of variable length, with rounded ends measuring 3 to 5 microns in diameter and pseudohyphae, have also been identified in infected tissues.[10] It can grow in at least three different morphologies: yeast, pseudohyphae, and hyphae. Other morphological forms exist during colony change; for example, opaque phase cells are oblong rather than the oval shape of yeast cells. Pseudohyphae and hyphae are elongated and sometimes indistinguishable, as both are "filamentous forms" of the fungus. Yeasts or blastospores are eukaryotic microorganisms that reproduce asexually by a specific process of cell division known as budding. This division process involves the production of new cell material from the surface of the blastospore.

DEVELOPMENT

Teeth whitening is a highly sought-after cosmetic procedure that has been researched since its inception. The most commonly used oxidizing agents in dentistry to achieve a whitening effect are hydrogen peroxide and carbamide peroxide in various concentrations and forms.[19] These oxidizing agents have proven helpful in clinically improving the aesthetic condition of teeth with endogenous and exogenous pigmentation. However, the biochemical basis of the whitening of these pigments has not been precisely elucidated, nor has the effect of these oxidizing molecules on the structural and molecular organization of teeth. Studies on the impact of hydrogen peroxide on morphological changes in dental tissues are contradictory but generally agree that hydrogen peroxide can alter the mineral content of teeth. Hydrogen peroxide for whitening releases calcium and phosphate ions, which increase as the concentration of peroxide increases.

Studies reporting its effect in correlation with microorganism adhesion date back to 1989 by Haywood and

Heymann.[21] The results obtained by Hosoya[20] and Anggakusuma[21], conclude that bacterial adhesion increases after the use of 35 % hydrogen peroxide and 35 % carbamide peroxide, respectively. Comparing 35 % hydrogen peroxide with other concentrations, the results are similar to those obtained by Al-Jubori[22] and Romero[23], who found that 7,5 % hydrogen peroxide significantly increases bacterial adhesion rates. Suttinee[31] found that biofilm formation of S. sanguis was considerably higher in enamel samples bleached with 35 % hydrogen peroxide than in other treatments but was lower in those bleached with 25 % hydrogen peroxide.

We can attribute these results to the enamel alterations caused by teeth-whitening agents.[2,15,18,23] These can modify its surface characteristics, leaving it more susceptible to bacterial adhesion. Likewise, bacterial adhesion to the enamel would increase by chemically altering the membrane binding sites on this surface. One of the adverse effects of teeth whitening is enamel erosion due to demineralization, which causes increased roughness in the tooth structure.[24] Surface roughness predisposes bacterial adhesion due to its essential role in developing oral bacterial biofilm. According to the literature, a rough surface can act as a buffer against shear forces and increase the area available for biofilm formation, thus promoting bacterial adhesion.[25]

This study aimed to compare the adhesion of C. albicans between two groups. This study showed that the control group had more excellent adhesion of this microorganism. This discrepancy could be due to the continuous release of peroxide by whitening products, which would cause a change in the biological balance within the oral cavity. Likewise, it has been reported that the release of oxygen by hydrogen peroxide has an antibacterial effect and a mechanical action on dental plaque.[27] This was similar for Zheng[26], who observed biofilm growth from the third week onwards, before which it was found to be reduced.

On the other hand, Ittatirrut[27] found no increase in biofilm formation after this tooth whitening method with 35 % hydrogen peroxide. Michelle35, in a double-masked controlled trial on the action of three whitening agents on the oral microbiota, concluded that it remained stable throughout the treatment. Similarly, Alkmin[36] evaluated the in vivo effects of whitening agents containing 10 % carbamide peroxide and 7,5 % hydrogen peroxide on Streptococcus mutans during teeth whitening. It concluded that there were no changes in the microorganism counts. The action of salivary lactoperoxidase could explain this. This oral enzyme catalyzes the reaction between thiocyanate and hydrogen peroxide, producing hypothiocyanate, which is much less toxic than hydrogen peroxide to bacteria, protecting streptococci against hydrogen peroxide. Philippe[36], in a comparative in vitro study of the action of lactoperoxidase in the formation of end products to prevent the formation of Candida biofilms, concluded that in the presence of hydrogen peroxide, this enzyme and its end products are active against biofilm formation. Tabata V[29] reported that applying hydrogen peroxide can alter the organization of the extracellular matrix, in addition to the disarticulation of the matrix with dispersed fungal cells after applying hydrogen peroxide in C. albicans biofilms compared to its control group. Others studied its use as an antimicrobial in removable prostheses,[28,40,41] as a disinfectant,[39] whose concentration was directly proportional to its cytotoxic effect on Candida, which can be in combination with another chemical or as an adjuvant to photodynamic therapy for periodontal antimicrobial treatment.[41,43] Ferguson[44] determined in an in vitro study that the minimum inhibitory concentration (MIC) of hydrogen peroxide for Candida was <0,63 μg/ml. Mc Donell[37] concludes that H2O2 in aqueous form with water as a vehicle is used as a good preservative antimicrobial on the skin, including wounds, and on inanimate surfaces. Recent technological advances have been made in the formulation of peroxide with other chemicals to improve antimicrobial activity at lower concentrations of the active agent for disinfection and sterilization. Nipomoga[32] agrees with the greater sensitivity of C. Albicans to the antimicrobial action of bleaching agents.

In contrast, Oliveira[44], in another study on the antimicrobial activity of four bleaching agents on six oral pathogens, C. albicans proved to be one of the most resistant. The literature on the antimicrobial effect of H2O2 is controversial. Further studies are needed to explain why the control group (without bleaching) had more Candida adhesion than the experimental group (with H2O2).

For future studies, we suggest increasing the sample size. The results of this study are limited by the use of extracted human teeth, which will inherently differ from vital teeth in the oral environment. For this trial, healthy premolars extracted for orthodontic reasons from patients between 15 and 35 years of age were used as samples. Other studies used third molars,[20,24,26] and other bovine teeth.[21,27] The protocols for obtaining and storing samples varied widely in the literature. Due to the lack of previous studies, we developed a protocol to determine how to get and store tooth samples, as we do not have a biobank for studies in Argentina. The collection and storage protocol was drafted based on a literature search. Still, we cannot determine that we implemented the correct one, assuming that a bias error can be attributed to this study stage. Based on the initial protocol, we developed a pilot study. After cleaning the data obtained, we adjusted the protocol for the final research. Likewise, there were no updated studies on the effect of professionally applied whitening with 35 % hydrogen peroxide on the adhesion of C. albicans to the tooth surface. Assessment by CFU counting is a quantitative method regularly used to determine the number of viable microorganisms in a medium. Hosoya[20] uses scanning electron microscopy to quantify the number of S. mutans colonies, which offers advantages. The choice of the vestibular surface of the selected teeth was based on the findings of Brosh et al.[30], who discovered

in their scanning electron microscopy (SEM) examination of untreated teeth that pronounced horizontal ridges or perikymata run continuously along the buccal surface of the tooth. At the same time, they appear to a lesser extent or not at all on the lingual surface. In addition, their SEM examination after the acid etching procedure showed that the lingual surface had a smoother macro pattern, smaller micropores, and a less pronounced wavy appearance after conditioning, allowing for less mechanical interlocking between the resin and the enamel. The authors hypothesized that the smoother appearance of the lingual surface was influenced by continuous contact with the tongue or the presence of salivary glands. Therefore, tooth whitening and C. albicans adhesion estimation should only be taken from the vestibular surface. In addition to the above, in professional practice, the agent is applied to the vestibular surface of the teeth, so we only considered the vestibular surface of the selected teeth from both the control and experimental groups to be of interest.

CONCLUSIONS

Teeth whitening is an increasingly popular cosmetic procedure based on the action of oxidizing agents such as hydrogen peroxide (H_2O_2). This agent, which is highly reactive and effective in removing chromogens, lightens teeth through oxidation-reduction reactions. However, its continuous use can cause adverse effects such as enamel demineralization, increased surface roughness, and alterations in bacterial and fungal adhesion.

Several studies have shown that hydrogen peroxide, especially in high concentrations such as 35 %, can influence the adhesion of microorganisms such as Candida albicans and Streptococcus mutans. Some results indicate that this agent may increase biofilm formation, while others highlight its antimicrobial effect, reducing the proliferation of oral pathogens. In this context, the scientific literature is contradictory, highlighting the need for further research to understand the biological implications of teeth whitening fully.

The present study concluded that the control group, without exposure to hydrogen peroxide, showed more excellent adhesion of C. albicans than the experimental group. This could be attributed to the continuous release of oxygen from the peroxide, which exerts antimicrobial effects and modifies the microbial balance in the oral cavity. However, the methodology used, which included the use of extracted human teeth, could limit the extrapolation of the results to real clinical conditions.

For future studies, it is suggested that the sample size be increased, advanced techniques such as scanning electron microscopy be used, and tooth collection and storage protocols be standardized. Furthermore, it is essential to investigate further the molecular and structural mechanisms underlying the effect of tooth whitening on enamel and the oral microbiota.

In conclusion, although teeth whitening is a valuable cosmetic tool, it should be used with caution, considering its potential side effects and the need for ongoing research to ensure its safety and efficacy.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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