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Effectiveness of Hydrogen Peroxide Concentrations on Bleaching and Tooth Sensitivity - A Systematic Review

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ABSTRACT

Background In this study, the literature was systematically reviewed to investigate the effect of hydrogen peroxide concentrations on bleaching effect and tooth sensitivity.

Data Sources: Electronic databases were screened, and hand searched. Searched electronic databases are PubMed, Scopus, Cochrane Library, Ovid Medline, Elsevier science direct, Wiley online library, Grey literature, Embase.

Materials and Methods: A systematic review on controlled clinical trials MeSH terms used are (hydrogen peroxide) AND (bleaching) AND (tooth sensitivity). A trial on the bleaching effect and tooth sensitivity with various hydrogen peroxide concentrations were included. PRISMA guidelines were followed, and the PICO model was used. Cochrane risk assessment tool for randomized controlled trials was used.

Results: A total of 5 articles fulfilled the inclusion criteria. The analysis showed that high hydrogen peroxide concentration has a better bleaching effect accompanied by tooth sensitivity. Low hydrogen peroxide concentration also has a bleaching effect slightly minimal from the former, followed by less tooth sensitivity.

Conclusion: This study concludes that the hydrogen peroxide with higher concentration is effective in bleaching and with lower concentration is less likely to produce tooth sensitivity

Keywords: H_2O_2, Bleaching, Sensitivity, Tooth shade, Aesthetic dentistry

INTRODUCTION

In contemporary clinical dentistry, aesthetic dentistry is one of the most dynamic areas. Through basic and clinical research, knowledge about esthetic dentistry has expanded over the past decade, which has led to the development of a multitude of new restorative materials and clinical technique. The tooth-coloured resin-based materials gradually enhance the quality of the esthetic restoration.[1]

To have a healthier and youthful appearance, an increasing number of people

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have begun to seek a white-toothed smile, which plays an important social role. The bleaching process comprises the application of the bleaching gel over the tooth surface for a longer duration of time, which may cause some damaging effects on its structure. The detrimental effects are sensitivity due to increased enamel porosity, gingivitis, and changes in enamel microhardness, increasing its surface roughness, throat and gastric irritation. Chapple described the first dental whitening technique in 1877.[2]

Tooth discolouration is mainly caused due to intrinsic and extrinsic stains. Intrinsic stains are also called internal staining, caused due to certain factors such as genetics, antibiotics, age, antibiotics, high levels of fluoride, and developmental disorders. Extrinsic stains are also called external stains, caused due to environmental factors, including antibiotics, smoking, pigments in beverages and foods and metals such as iron or copper. The mechanism is that the coloured compounds from these sources are adsorbed into the acquired dental pellicle, causing a stain to appear.[3]

The bleaching technique is a procedure, involves the lightening of the tooth colour by application of a chemical agent to oxidize the organic pigmentation in the tooth. The most commonly used materials for bleaching are hydrogen peroxide (HP) and carbamide peroxide (CP). These oxidizing materials cause initial diffusion into enamel and dentin, then breaks down to produce unstable free radicals. "Whitening effect" is obtained when these free radicals attack organic pigmented molecules by reflecting less light. The most frequently used vital bleaching techniques are in-office (power bleaching) and at-home bleaching techniques. Other variables like concentration and type of bleaching agent are used and their application time in these two bleaching techniques. The most common side effects of bleaching treatment are "tooth sensitivity", which normally persists for up to 4-7 days after the conclusion of bleaching treatment. Tooth sensitivity during the bleaching technique is associated with microscopic surface defects and subsurface pores in the enamel. It has been proposed that tooth sensitivity occurs when these surface defects allow rapid access to the pulp's whitening agent.[4]

H_2O_2 is the molecular formula for hydrogen peroxide, a clear, colourless liquid with no odour, and its molecular weight is 34.0128. Hydrogen peroxide is quite unstable, and through slow decomposition, it releases oxygen. This decomposition is accelerated by light and heat, which is noted in all power bleaching technique. Though hydrogen peroxide in high concentrations can be toxic and with prolonged exposure, concentrated 30-35% of H_2O_2 have been used for in-office bleaching techniques. Except for post-treatment sensitivity, there are no major adverse effects on soft and hard tissues. H_2O_2 is completely soluble in water and gives an acidic solution. One per cent solution has a pH of 5.0-6.0.[5] Hence this systematic literature review evaluates the effect of hydrogen peroxide concentrations in bleaching and tooth sensitivity.

MATERIALS AND METHOD

STUDY DESIGN

This study is a systematic literature review of clinical trials using hydrogen peroxide and the effectiveness of various hydrogen peroxide concentrations in the intensity of bleaching and tooth sensitivity.

SEARCH STRATEGY

Electronic databases used to find the effectiveness of hydrogen peroxide concentration in bleaching and tooth sensitivity are PubMed,

Scopus, Cochrane library, Ovid Medline, Elsevier science direct, Wiley online library, Grey literature, Embase. MeSH terms were used in the databases to identify the articles. The MeSH terms used were hydrogen peroxide AND bleaching AND tooth sensitivity.

ELIGIBILITY CRITERIA FOR THE STUDY

INCLUSION CRITERIA

- Articles on the effectiveness of hydrogen peroxide in bleaching and tooth sensitivity.
- Clinical trial studies.
- Full-text articles.
- Publications over the years.
- In-vivo studies.
- Articles that are in the English language.

EXCLUSION CRITERIA

- Only abstracts available.
- Unrelated articles.
- In-vitro studies.
- Review articles.

SEARCHED DATABASES

- PubMed
- Cochrane library
- Ovid Medline
- Elsevier science direct
- Wiley online library
- Grey literature
- Embase

Flow chart: 1 Flow chart diagram showing the number of studies identified, screened, assessed for eligibility, excluded, and included in the systematic review

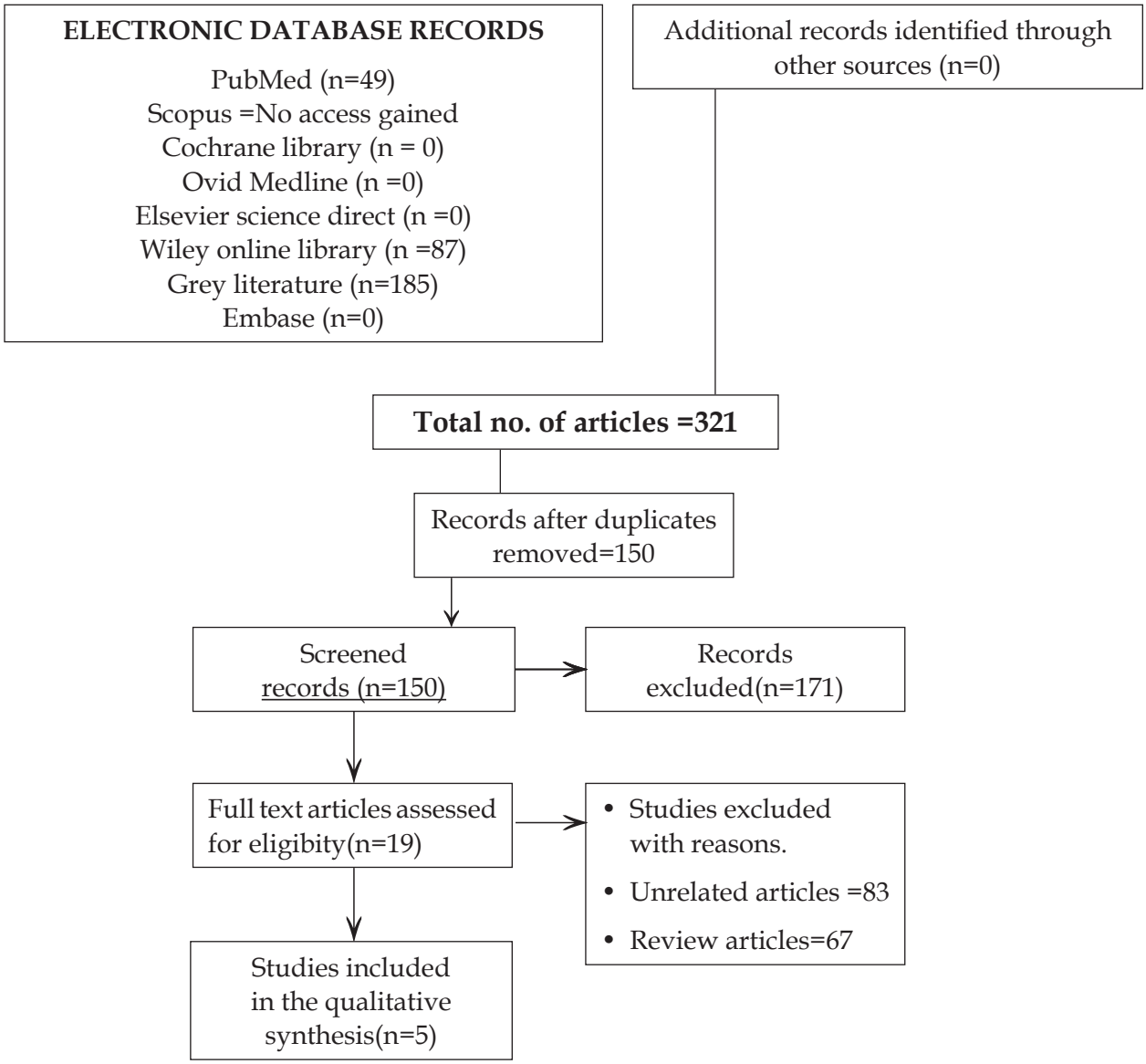

Table 1: Characteristics of Interventions Included in the Study

S.no	*Author name*	*Year*	*Patient selection*	*Duration*	*Preparations used*	*Interventions*
1	Marcela Leticia Leal Goncalves et al.[6]	2017	53 patients aged 11 to 12 years	-	Hydrogen peroxide gel	**Group 1:** Whitening hydrogen peroxide 35% **Group 2:** Whitening hydrogen peroxide blue 35% **Group 3:** Whitening hydrogen peroxide blue 20%
2	Suellen Nogueira Linares Lima et al.[7]	2017	25 volunteers aged between 18 to 40 years old	14 days	Hydrogen peroxide gel preparations	**Group 1:** Hydrogen peroxide 35% **Group 2:** Hydrogen peroxide 15%
3	J.F. Bortolatto et al.[8]	2014	40 volunteers aged between 18-25 years old	21 days	Hydrogen peroxide gel preparations	**Group 1:** Hydrogen peroxide 15 % **Group 2:** Hydrogen peroxide 35%
4	J. Martin et al.[9]	2015	31 patients over 18 years old	21 days	Hydrogen peroxide gels	**Group A:** 35% hydrogen peroxide **Group B:** 6% hydrogen peroxide with nitrogen-doped titanium dioxide light
5	A Reis et al.[10]	2013	60 volunteers with atleast 18 years old	Nine days	Hydrogen peroxide gels	**Group 1:** Hydrogen peroxide 35% **Group 2:** Hydrogen peroxide 20%

Table 2: Outcome of the Data Included in the Studies

S.no	*Author*	*Year*	*Outcome*	*Result*
1	Marcela Leticia Leal Goncalves et al[6]	2017	Visual analogue scale Group 3 reported less sensitivity in comparison to group 1 and group 2 Greater bleaching occurred in group 1 when compared to group 2 and group 3	Tooth sensitivity is lesser in group 3, in which the intervention is Whitening hydrogen peroxide blue 20%
2	Suellen Nogueira Linares Lima et al[7]	2017	Tooth sensitivity assessed using a visual analogue scale and numerical rating scale. Group 1 showed higher tooth sensitivity than group 2	Tooth sensitivity is lesser in hydrogen peroxide 15% groups
3	J.F. Bortolatto et al. [8]	2014	Tooth sensitivity assessed using a visual analogue scale (low, average, high, very high). Group 1 showed lesser sensitivity than group 2	Tooth sensitivity is lesser with hydrogen peroxide 15 %
4	J. Martin et al.[9]	2015	No significant change in colour and tooth sensitivity for both groups. Tooth sensitivity assessed using a visual analogue scale.	Tooth sensitivity is similar in both group A (35% hydrogen peroxide) and group B (6% hydrogen peroxide with nitrogen-doped titanium dioxide light)

S.no	Author	Year	Outcome	Result
5	A Reis et al.10	2013	Tooth sensitivity was recorded on a 0-4 scale and bleaching efficacy using the Vita Classical shade guide. No significant change in tooth sensitivity for both the groups and 35% hydrogen peroxide showed faster bleaching	The tooth sensitivity intensity is similar in group A (35% hydrogen peroxide) and group B (20% hydrogen peroxide), and the bleaching efficacy is greater with 35% hydrogen peroxide.

FLOW CHART 1: The total number of articles retrieved from the electronic databases are 321. Out of 321, 150 articles were assessed and screened for eligibility of the study and 171 articles were excluded. From 150 articles, 19 full-text articles were retrieved, excluding 85 unrelated articles and 67 review articles. Eventually, for qualitative synthesis, four studies were included.

Table 1: Shows the characteristics of interventions included in the study. In all the above four studies, the effect of hydrogen peroxide on tooth bleaching and tooth sensitivity was compared and reviewed.

Table 2: Shows the outcome and result of the five studies included in the systematic review

TOOTH SENSITIVITY ASSESSMENT IN THE INCLUDED STUDIES

- The Visual Analogue Scale (VAS) employs a 10-cm horizontal line with the words "no pain" at one end and "worst pain" at the opposite end.

	Score
None	0
Mild	1
Moderate	2
Considerable	3
Severe	4

- The NRS comprises the following criteria:

Table 3: Bias Analysis for the Included Studies

S. no.	Author and Year	Random Sequence Generation	Allocation Concealment	Selective Reporting	Incomplete Outcome Data	Blinding Of Outcome Assessment	Blinding Participants And Personals
1	Marcela Leticia Leal Goncalves et al[6]	-	-	-	-	?	?
2	Suellen Nogueira Linares Lima et al7	-	-	-	?	-	-
3	J.F. Bortolatto et al.[8]	-	-	?	?	-	-
4	J. Martin et al.[9]	-	-	-	-	-	-
5	A Reis et al.[10]	-	-	-	-	-	-

The bias is assigned as low risk (-), high risk (+), and unclear (?)

DISCUSSION

According to the literature, following the manufacturer's protocol, the tooth whitening procedure is safe and effective, yet the profession and the users should be aware of the risks. Increased tooth sensitivity and gingival irritation are certain risks related to tooth whitening, and the profession and public are aware of it. Current research also shows that degradation of dental restorations, tooth surface roughening and softening, increased potential for demineralization and unacceptable colour change of dental restorations. To increase the persistence of whitening and to reduce tooth sensitivity by optimizing the whitening procedure is focused on new research.[3]This present study aims to determine hydrogen peroxide concentration on tooth whitening and tooth sensitivity through a systematic review. A total of 4 articles were selected and retrieved based on the inclusion and exclusion criteria from the electronic database.

(TABLE 1) In 2017, Marcela Leticia Leal Goncalves et al., done a randomized, controlled clinical trial on In-Office bleaching using 20% and 35% hydrogen peroxide for patients aged between 11 to 24 years. (TABLE: 2) Vita Classical Shade guide and the visual analogue scale was used for the change in the tooth colour and tooth sensitivity, respectively. Reduction in tooth sensitivity was detected in lower concentrations of hydrogen peroxide 20%. Increased sensitivity was seen in 35% hydrogen peroxide. There is a significant colour change after each of the two bleaching sessions, and the study showed statistically significant with $p \leq 0.05$. These clinical trial studies not mentioned the blinding of either the participants or the observer and also unclear in the blinding of outcome assessment.[6]

(TABLE 1) In 2017, Suellen Nogueira Linares Lima et al. conducted a randomized double-blinded clinical trial using 15% and 35% hydrogen peroxide on 25 volunteers. Tooth sensitivity was scored using a visual analogue scale and numerical rating scale, and subjective and objective methods determined the bleaching efficacy. The bleaching effect was higher in hydrogen peroxide 35%, and the reduction in tooth sensitivity is seen in hydrogen peroxide 15%. (TABLE 2) This study concluded that the low concentration hydrogen peroxide, i.e. 15%, should be considered a good treatment alternative for in-office bleaching than the higher concentration for in-office bleaching because it generates greater risk and increased tooth sensitivity for patients. The p-value is not statistically significant in this study. This study has a lower risk in random sequence generation, allocation concealment, reporting, performance and detection bias. In attrition bias reason for the dropout has not mentioned; hence it is unclear.[7]

(TABLE 1) F. Bortolatto in 2014 conducted a randomized double-blinded clinical trial on 40 healthy volunteers of both male and female aged between 18 and 25 yrs to test the efficacy and tooth sensitivity of an in-office 15% H2O2 bleaching agent containing nanoparticles of TiO N photocatalyzed with LED/laser light (HP15) and a control of 35% H2O2 (HP35). Reflectance spectroscopy was used to evaluate the bleaching efficacy. A visual analogue scale was used to evaluate tooth sensitivity. (TABLE 2) He concluded that the hydrogen peroxide 15% (lower concentration) reduces tooth sensitivity and promotion in efficacy compared to the control group hydrogen peroxide 35%. This randomized clinical trial study has a lower risk of detection and performance bias.[8]

(TABLE: 1) In 2015, J. Martin et al.[9] conducted a randomized clinical, double-blinded, split-mouth study on 31 patients with 35% H_2O_2 in one upper arch and 6% H_2O_2 in the other upper arch. Tooth shade was evaluated using the VITA Classic guide, and VAS assessed tooth sensitivity. (TABLE:2) He concluded that there is no clinical difference between both groups with a p-value <0.05, which is statistically significant. This study also reported as the clinical significance that good clinical results with minimal adverse effects

might be reached with a low concentration of hydrogen peroxide bleaching agent. Like the previous study mentioned above, the tooth sensitivity was evaluated using a visual analogue scale, and the tooth colour efficacy was evaluated using the colorimeter method. The study concluded that the H_2O_2 ozone combination efficacy is greater and satisfying, whereas H_2O_2 38% increased the bleaching sensitivity.[9]

(TABLE: 1) A Reis et al.[10] in 2013 conducted a randomized, double-blind, parallel-group clinical trial on 60 volunteers who are atleast 18 years old, group 1 is hydrogen peroxide 35%, and group 2 is hydrogen peroxide 20%. Tooth sensitivity was recorded on a 0-4 scale and bleaching efficacy using the Vita Classical shade guide. (TABLE 2) The tooth sensitivity intensity is similar in both group A and group B, and the bleaching efficacy is faster in group B 35% hydrogen peroxide. [10]

In 2017 Mahmoud K. AL-Omiri conducted a randomized controlled trial on 45 participants who were randomly allocated into three groups (n=15). Group 1 participants are treated with ozone for 60 seconds and then 38% H_2O_2 for 20 minutes. Group 2 participants were treated with 38% H_2O_2 for 20 mins, followed by ozone for 60 secs, followed by air produced by the heal ozone machine for 60 secs. Group 3 participants are treated with 38% H_2O_2 for 20 mins which was considered a control group. Same as the previous study mentioned above, the tooth sensitivity was evaluated using a visual analogue scale, and the tooth colour efficacy was evaluated using the colorimeter method. The study concluded that the H_2O_2/ozone combination efficacy is greater and satisfying, whereas H_2O_2 38% increased the bleaching sensitivity.[11] A Reis et al in his study concluded that in-office bleaching gels i.e 35% and 20% hydrogen peroxide showed similar tooth sensitivity but faster bleaching is achieved by 35% hydrogen peroxide. [10]

Studies on systematic review and meta-analysis of Li-Bang He et al evaluated the influence of light on bleaching efficacy and tooth sensitivity at in-office vital tooth bleaching. Their study concluded that light-activated system produced instant superior bleaching effects when low concentrations of hydrogen peroxide is used i.e., 15-20% than the non-lightactivated system. Bleaching effect is not improved at higher concentration through light activated system. Light activated system also increases the risk of tooth sensitivity.[12]

Silveira Machado et al in 2014 said that bleaching with 10% hydrogen peroxide was effective without tooth sensitivity during applications in a short period of time.[13] Most recently in 2021 Marcelo et al. evaluated the effect of violet illumination on tooth whitening alone and with combination of 35% hydrogen peroxide on bovine teeth. The result obtained by Marcelo was Violet illumination with hydrogen peroxide gel treatment completely restored the teeth whiteness caused by coffee staining. Concluded that Violet illumination with gel treatment can be recommended for the stains caused by drinking coffee.[14]

Several studies were performed with different concentrations of hydrogen peroxide to produce better results with minimal adverse effects. However, most studies stated that the desired bleaching effect could be obtained with higher concentrations along with minimal tooth sensitivity reactions.

LIMITATIONS

This present study included only five articles related to hydrogen peroxide's effectiveness in the bleaching effect and tooth sensitivity. Based on the inclusion and exclusion criteria, various other studies have been excluded. Many other trial studies are required to establish the bleaching effect of hydrogen peroxide and its tooth sensitivity effect based on its concentrations.

CONFLICTS OF INTEREST: None.

CONCLUSION

This study concludes that hydrogen peroxide with higher concentration is effective in bleaching and with lower concentration is less

likely to produce tooth sensitivity. The quote "With bad comes good" implies that the bad is tooth sensitivity, and good is an esthetic bleaching effect. People with an esthetic mind should go through the tooth sensitivity effect, which fades out later to have white teeth.

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