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Bleaching Effectiveness and Tooth Sensitivity of Inoffice Hydrogen Peroxide Containing Titanium Dioxide Based Bleaching Agent: A Systematic Review

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Review Article

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ABSTRACT

Tooth bleaching is considered to be conservative, noninvasive and cost effective treatment modality in regards to esthetic consideration. Inoffice bleaching is one of the types of vital bleaching. Most current office bleaching products contains high concentration of hydrogen peroxide which in turn has various deleterious effects on tooth structure, pulp tissues and mucosal tissues of the mouth. In addition, the high concentration often causes postoperative dentin hypersensitivity. In view of the safety, lower concentration of bleaching agent is desirable. Recently visible light activating Titanium dioxide has been introduced as photo catalyst which lowers the concentration of hydrogen peroxide by accelerating its breakdown thereby enhancing the rate of bleaching. The aim of this systematic review is to know the influence of lower percentage of hydrogen peroxide on the bleaching efficacy and tooth sensitivity in TiO_2 containing inoffice bleaching agent in randomized clinical trials.

INTRODUCTION

Dental bleaching has been considered the most accepted dental treatment in regards to esthetics as it provides conservative, non-invasive and cost effective treatment. Inoffice vital tooth bleaching is one of the techniques where the bleaching agent is applied in the office by the dental professionals [1-5]. The advantages of an in office bleaching over at home bleaching techniques are control over procedure , prevention of deleterious effect of bleaching material on soft tissue without its ingestion, reduced total treatment time, provides immediate results and increases patient satisfaction and compliance [6]. The most commonly used in office bleaching agent is hydrogen peroxide. Hydrogen peroxide is an oxidizing agent. It produces free radicals and these free radicals then act on the pigmented organic molecules which are further broken down. These broken down molecules will either diffuse through the tooth or will reflect less light [7] and results in effective bleaching. The concentration of hydrogen peroxide is relatively high when used for in office procedures which are the range of 30-35% [8]. The high concentration results in deleterious effects on tooth structure, pulp tissues and mucosal tissues of the mouth with subsequent postoperative sensitivity [9,10]. Therefore the efforts were made in the direction of reducing its concentration and achieving the same bleaching efficacy without any adverse consequences.

Bleaching efficacy has been evaluated by various subjective and objective methods such as value oriented shade guides, colorimeter and digitized photographs. The subjective methods are done with visual analysis, are not reproducible and are effected by various factors such as lighting, eye fatigue, observers experience while objective methods provides parametric data which can be subjected to statistical analysis [11]. Dentin hypersensitivity post bleaching treatment has been experienced by the patients and results in discomfort and discontinuation of the treatment. Teeth sensitivity is associated with higher concentrations and longer application time with the bleaching product [12,13]. Recently nitrogen duped visible light activating titanium dioxide which acts as photo catalyst has been added in inoffice vital bleaching materials. The addition of titanium dioxide lowers the concentration of hydrogen peroxide by accelerating its breakdown and enhancing the rate of bleaching [1]. Various studies have been published using this material. Thus this paper emphasizes on systematic review of the studies published in the dental journals involving titanium dioxide as photo catalyst for in office vital bleaching with hydrogen peroxide on bleaching efficacy and tooth sensitivity.

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METHODOLOGY

The literature was searched with predefined inclusion and exclusion criteria **(Table 1)** on Google and Pubmed in August 2016 with the keyword of Titanium dioxide dental bleaching, hydrogen peroxide and titanium dioxide dental bleaching, Tooth bleaching. The articles found were further searched in their references.

Table 1. Criteria for inclusion and exclusion of studies.

Inclusion criteria
Randomized controlled clinical trial
A minimum sample size of at least 20 patients at baseline, with mild discoloration in the age of 18years or older, without any medical history
In office vital bleaching technique
Hydrogen peroxide with Nitrogen duped titanium dioxide was compared with hydrogen peroxide alone
Hybrid LED and Laser light was used for activation
Treatment outcome was bleaching efficacy or tooth sensitivity or both
Exclusion criteria
In vitro studies
In office nonvital bleaching technique
Carbamide peroxide or bleaching agent other than hydrogen peroxide was used for comparison
Case reports

Data Collection

Data was recorded in the following headings for qualitative analysis: Type of study, sample size, age group, bleaching material used, treatment time and hybrid light used with specifications, bleaching efficacy, tooth sensitivity.

RESULTS

The search resulted in total of 45 articles and after removal of duplication resulted in 21 articles. The 16 studies were excluded (invitro studies (9), case report (4), opinion (1), clinical studies (2)) and five studies 1, 2, 3, 4, 5 were included for this review **(Figure 1)**.

The included studies were double or triple blind randomized clinical trial with split or parallel study design having a minimum of 20 patients in each group of 18-37years. The teeth bleached were either from first premolar to first premolar or canine to canine in upper arch or all anterior teeth .The Bleaching time, Bleaching efficacy and Dentinal sensitivity of the included studies were shown in **Table 2**.

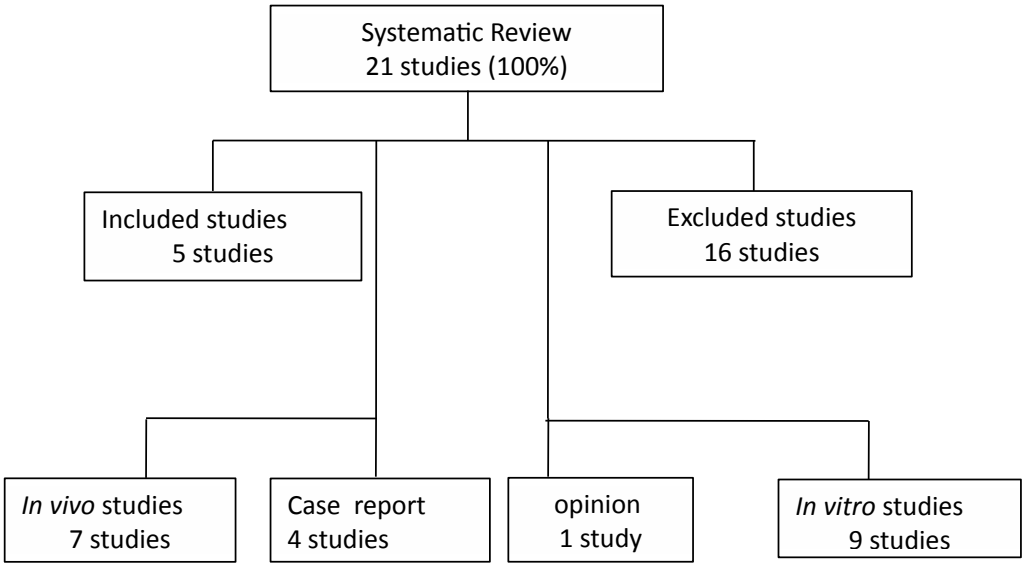

Figure 1. Distribution of retrieved studies in the present systematic review.

DISCUSSION

This systematic review was conducted to evaluate the bleaching efficacy and tooth sensitivity of an in office hydrogen peroxide and nitrogen duped visible light titanium dioxide ($VLTiO_2$) based bleaching agent in randomized clinical trials. The inoffice

Table 2. Titanium dioxide bleaching activation (clinical trials).

Author/study	Sample/ Age Group/ Teeth bleached	Bleaching material/ Manufacturer/ active ingredient	Contact time App (time), Session (time), Total time	Bleaching Light		Bleaching efficacy (Color assessment)		Tooth Sensitivity
				Photocatalysation	Commercial name, spectrum, power	visual/instrumental, repeatability, Position	Timings, shade, color, Result	Measurement method, occurrence, Result
Bartolatto [1] Double blinded randomized parallel study (Patient and evaluator)	40, 20 in each group, 18-25 years, 16 teeth between first premolar (U and L)	**GI:** Lase Peroxide Lite, DMC, São Carlos, Brazil, 15% H_2O_2 containing TiO_2 **GII:**Lase Peroxide Sensy, DMC, São Carlos, SP, Brazil; 35% H_2O_2	**GI:** 3(16 mins), 3(48 mins), 144 mins **GII:** 3 (15 mins), 3 (45 mins), 135 min Interval between session was 7 days	**GI:** With Photocatalyzation activated 4 times with alternating irradiance every 2 min for each arcade, Total time was 144 min, **GII:** Without Photocatalyzation	Whitening Lase II; 6LED 470 ± 15 nm, 300 mW each,generator of 1800 mW Power, 3 infrared laser diode 810 nm, 200 mW generator of 600 mW; 300 mW/cm^2	Spectrophotometer (Vita Easyshade); NS; Positioned in the middle third of the labial surface, following the manufacturer's instructions	Immediately, after First, second and third Session. Shade by LAB parameter and color alteration from baseline by Delta E, Efficacy of HP15 was greater than the HP35.	VAS using 100 mm scale scored by patients; Yes or no reporting of sensitivity; The bleaching agent with the lower concentration (HP15) promoted lower levels of tooth sensitivity compared to the control (HP35)
Martin [2] Double blinded randomized, split mouth study (Patient and Evaluator)	30, 30 for both groups over 18 years of age 8 teeth between first premolar (Upper)	**GI:** NS; 6% H_2O_2 containing TiO_2, **GII:** NS; 35% H_2O_2	GI and GII 2 (12 mins); 3 (24 mins); 72 mins Interval between session was 7 days	GI and GII: With Photocatalyzation For each application continuous irradiation for 12 mins	Bleaching Lase Plus, Blue hybrid light with an infrared laser NS, 1500 mW	value-oriented shade guide (Vita classical) and Spectrophotometer (Vita Easyshade Compact); Custom guide; Positioned in the middle third of the labial surface within the area of 6 mm of the right and left central incisor	immediately after First, Second and Third Session, one week and one month after the Third session Shade by change in no of shade guide units from baseline and LAB parameter and color alteration from baseline by Delta E Teeth bleached with 35% bleaching compound had greater effectiveness however 6% compound was considered effective.	Self completed forms after each session and clinical evaluation using VAS used a 100 mm scale by patients; Yes or no reporting of sensitivity; Intensity: None, mild, moderate, considerable, severe 6% hydrogen peroxide with nitrogen-doped titanium dioxide light activated agent showed no clinical differences to 35% agent in tooth sensitivity.

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Martin [3] Double blinded randomized Parallel study	70, 35 in each group 18 years or older All anterior teeth (U and L)	**GI:** Lase Peroxide Lite, DMC, São Carlos, Brazil; 15% H_2O_2 containing TiO_2 **GII:** Lase Peroxide Sensy, DMC São Carlos, Brazil; 35% H_2O_2	**GI:** 3 (15 mins), 1 (45 mins), 45 mins, **GII:** 3 (12 mins), 1 (36 mins), 36 mins	GI & GII: With Photocatalyzatio, Manufacturer instructions	Whitening Lase Light Plus; infraed laser 808 nm and blue LED 450 nm infrared 100 mW and blue LED 400 mW	value-oriented shade guide (Vita classical) using digital spectrophotometer SpectroShade Micro	Immediately, 1 week and 1 month after first session, Shade by change in no of shade guide units from baseline, No differences between groups	Before and immediately after treatment by VAS, controlled BS symptoms objectively through blast of air. Before treatment 12 VAS units for group 1 and 18 for group 2, with no differences between them. 15% hydrogen peroxide gel with N_TiO_2 permits less pulpal sensitivity than using 35% hydrogen peroxide
Bartolatto [4] Triple blinded randomized Parallel study (POE)	48, 24 in each group, 18-25 years, 16 teeth between first premolar (U and L)	**GI:** Lase Peroxide Lite 6 %, DMC, São Carlos, Brazil, 6% H_2O_2 containing TiO_2 **GII:** Total Blanc, Nova DFL, Rio de Janeiro, RJ, Brazil 35% H_2O_2	**GI:** 2 (16 mins), 2 (28 mins), 56 mins, GII: 2 (16 mins), 2 (28 mins), 56 mins Interval between session was 7 days	GI: With Photocatalyzatio, GII: Without Photocatalyzation Activated 6 times with alternating irradiance every 1 min for each arcade in each application of 12 mins	Whitening Lase Light Plus, 6 LEDs 470 ± 15 nm, 300 mW each and 3 infrared laser diode 810 nm, 200 mW; 300 mW/cm^2	spectrophotometer (vita Easy shade Advance); Custom guide; Positioned in the middle third of the labial surface within the area of 6 mm of the right and left central incisor	7 days after First session and Second session; Shade by LAB parameter and color alteration from baseline by Delta E 6% hydrogen peroxide gel produced reduced efficacy compared to 35% concentration	Self completed forms after each session; Yes or no reporting of sensitivity; Intensity-none, mild, moderate or severe; 6% hydrogen peroxide gel produced less tooth sensitivity. compared to 35% concentration Duration-1 sec, 1 min, 5 min, 1 hour, more than1 hour
Martin [5] Double blind randomised parallel study	88 divided into 3 groups 18-37 years Canine to canine	**GI:** Lase Peroxide Lite; DMC, São Carlos, Brazil; 15% H_2O_2 containing TiO_2 **GII:** Lase Peroxide Sens 35% H_2O_2 **GIII:** Whitegold Office 35% H_2O_2 (NP)	**GI:** 3 (15 mins), 1 (45 mins), 45 mins, **GII:** 3 (10 mins), 1 (30 mins), 30 mins **GIII:** 1 (45 mins), 1 (45 mins), 45 mins	**GI and GII:** With Photocatalyzation alternately irradiating each arcade with 1 min, 30s (GI) and 1min (GII) cycle and completing five cycles of luminous activation per arch in each application, GIII: Without Photocatalyzation	Whitening Lase Light Plus, 6LEDs 470, 1800 mW power and 3 infrared laser diode 830 nm,450 mW of power	NA	NA	Before and immediately after treatment by VAS, controlled BS symptoms objectively through blast of air, Both groups showed increased sensitivity immediately after treatment. 15% Group displayed less changes relative to baseline with no significant differences

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bleaching material hydrogen peroxide (either 6% or 15%) catalyzed by nitrogen duped visible light titanium dioxide activated by hybrid LED/laser light was compared with 35% hydrogen peroxide used alone and activated by Hybrid LED/Laser light.

The bleaching effectiveness was measured by comparing the tooth colour with baseline before application from immediately or after 1 week or 1 month after product application in the included studies. Hussan et al. in his systematic review found that the studies had measured effectiveness immediately after 2 weeks of product application [14]. The bleaching agent application was done in one, two or a maximum of three sessions. This may be due to the finding that one session was sufficient for noticeable degree of whitening but the rate of color regression was decreased with two sessions over one session [15]. The color assessment in the included studies was done with digital spectrophotometer with or without value oriented shade.

Bleaching effectiveness of lower concentration of hydrogen peroxide with titanium dioxide compared with 35% hydrogen peroxide used alone has resulted in either no clinical difference between the groups [2] or greater bleaching efficacy [1]. The greater efficacy was justified on the basis of using LED/laser light and heterogenous advanced oxidative process modulated by TiO_N nanoparticles [1]. However another study found [4] that lower concentration has given the lowest bleaching result which was explained on the basis of the bleaching protocol used in the clinical trial has resulted in reduced contact time of 6% hydrogen peroxide with nitrogen duped titanium dioxide by half the recommended time as proposed by the manufacturer [4].

It was found that the sensitivity and bleaching outcome has been related to the concentration and the total application time of the bleaching agent on the tooth structure [12,13]. The higher concentration and more contact time leads to ingress of hydrogen peroxide and its degradation product in the pulp chamber producing a reversible inflammatory response [16]. The previous study [17] on contact time has found that the three application of 15 mins in office bleaching rather than single application of 45 mins with 35% of hydrogen peroxide has resulted in effective bleaching efficacy and reduced tooth sensitivity.

It was observed that the combination of nitrogen duped TiO_2 activated by visible light to hydrogen peroxide leads to its lower concentration and causes less dentinal sensitivity after treatment. Also these contemporary bleaching agents are safer and more efficient than the conventional bleaching agents [18]. The included studies also show the similar results.

The use of hybrid LED/laser light resulted in effective bleaching efficacy and reduced tooth sensitivity with 15% hydrogen peroxide compared when compared with 35% hydrogen peroxide [1,3]. Also previous study [19] has found that the use of hybrid LED/Laser light resulted in a significant reduction of tooth sensitivity and the treatment time was reduced by 53% with the same bleaching efficacy with 35% hydrogen peroxide without the light source. This may be explained by the efficacy of the hybrid light which causes little change in pulp chamber temperature and the temperature increase did not exceed 2°C, at the same time it resulted in polarization of the nerve fibres and leading to reduced sensitivity in both the groups [20]. The results of *in vitro* study [18] in rat experimental model have observed less inflammatory response of the pulp chamber when compared with in office bleaching without hybrid activation irrespective of the concentration of bleaching agent used which indicates the therapeutic effect of the infrared laser in the hybrid light.

Dentin hypersensitivity can be assessed either by stimulus based assessment or response based assessment. The stimulus based method uses stimulus intensity to provoke pain while response based methods needs subjective evaluation of the pain produced by a defined stimulus [21]. The dentin hypersensitivity may be different for different stimuli therefore it is advised that at least two different stimuli should be used in stimulus based methods [22]. The tooth sensitivity was evaluated in the included studies in terms of occurrence [2,4], intensity [2,4], duration [4] and type [4] and these were noted in the self-completed forms by the patient after each bleaching session. The patients were also provided 100 mm visual analog scale [1-3,5] and were asked to respond by VAS scoring when the upper central incisors were stimulated by activating an air syringe for 2 s at a distance of 1 cm from the tooth surface.

In regards to occurrence of tooth sensitivity there was statistically significant difference [1,3,4] between the groups. The 35% hydrogen peroxide treatment has resulted in highest intensity and longer duration of sensitivity than 6% hydrogen peroxide [1]. However no difference [2] between the groups was also reported and this was explained on the use of infrared laser which resulted in polarization of the nerve fibres and subsequently the reduced sensitivity in both the groups.

CONCLUSION

The following conclusion can be drawn from the present review:

1. The recently introduced nitrogen duped titanium dioxide when added to low concentration of hydrogen peroxide has resulted in effective tooth bleaching and good clinical results with less dentinal sensitivity.

2. The hybrid lights (LED and Laser) used has resulted in better results.

The studies have evaluated the results for a short term follow ups. Further studies are needed to evaluate the long term clinical results.

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